Electrical Engineering

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American Institute of Electrical Engineers

Engineers' Week—June 26-30

At the Convention—

Those attending the Institute's 49th annual summer convention at Chicago during Engineers' Week will have the choice of a wide variety of technical activities in addition to the entertainment features afforded by the convention program and the galaxy of opportunities offered by the Exposition.

The Institute's technical program embraces 6 technical sessions with some 30 critically selected papers revealing many of the latest developments in the art and science of electrical engineering and their reflection in the design and operation of electric equipment. The annual meeting of the Institute also will be held.

Engineers' Day, Wednesday June 28, will be celebrated at the Exposition with a series of special features of interest to engineers. No technical sessions will be held that day. During the week several sessions will be held jointly with the Econometric Society and with national engineering societies.

Golf, tennis, and other tournaments have been arranged by the sports committee. Golf events include play for the Mershon and the Lee trophies and for the District team championship. Several affairs have been arranged especially for the women, who will doubtless enjoy the atmosphere of the Edgewater Beach Hotel.

Exceptionally low transportation rates are available from practically all parts of the country. Also special rates for the convention have been provided by the Edgewater Beach Hotel which, with its Lake Michigan frontage and its unusual recreational facilities, will be convention headquarters.

Hotel reservations should be made immediately by those planning to attend the convention.

At "A Century of Progress"—

A general charge of 50 cents for adults and 25 cents for children for admission to the grounds provides free entry to the 20 Fair buildings and also to the 33 special exhibition buildings. Exhibitors and concessionnaires have contracted for more than $12,000,000 worth of special buildings and facilities.

Windowless buildings are the rule; ceiling and cove lights are generally used for interiors—concealed colored lights emphasize the mass effect of exteriors while retaining serenity and dignity. Of the 40,000-kva total connected lighting load, the exterior illumination requires 12,000 kva.

Guarding the crowds are 300 scarlet coated police resplendent in white helmets and black trousers with yellow stripes, and carrying white bamboo swagger sticks. Guiding the crowds are 2,000 college graduates who survived drastic physical and mental tests; they wear a colorful military-type uniform.

A $20 gold piece is available to any one who can get by a photoelectric burglar alarm. Photoelectric cells will be called into service to prevent the lighting of a candle, sort black and white balls as they roll down a chute, clear smoke out of a glass chimney, and count the flickers of an incandescent lamp.

Houses of ready-made units capable of assembly in days instead of months are on exhibition in a group that includes 2 of all-steel construction, 3 of wood composition materials, one of stone composition, one all wood, one all brick including floors, and one of glass. All are completely furnished.

Traffic facilities are provided to handle 600,000 people per day on the 3-mile length of the Fair.

The 1933 Century of Progress Exposition

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This Month—*Summer Convention Issue*

Front Cover

U.S. Government building on Northerly Island at "A Century of Progress" Chicago 1933 International Exposition (looking across the lagoon from the mainland). The 3 towers symbolize the 3 branches of the government: legislative, judicial, administrative. Behind its spacious wings are the buildings of the States. Photo by Mario Scacheri

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ACTIVITIES of A.I.E.E. Sections and Branches were "up to par" during 1932. *p. 426–8*

AIR CONDITIONING is being developed for the home, and already several types of equipment are available. *p. 366–71*

WINNERS of prizes awarded by the Institute for technical papers presented during 1932 recently were announced by the committee. *p. 424–5*

PRECISE timing of athletic and other sporting events has been made possible by a recently developed electrical timing system. *p. 386–91*

2 MILLION hp in a single plant is the proposed ultimate generating capacity of the Beauharnois hydroelectric development on the St. Lawrence River. *p. 377–84*

THE scheduling of several papers of wide general interest is one factor which contributed to the success of the ninth annual meeting of the A.I.E.E. North Eastern District. *p. 423–4*

RELAYING high voltage open wire lines interconnecting 2 or more electric power systems presents problems not ordinarily found in the relaying of intra-system lines. *p. 402–09*

AN ACCELERATED aging test has been developed for high voltage electric power cables which produces in a few weeks about the same deterioration as that resulting from years of service. *p. 371–7*

FINAL arrangements for the Institute's 49th summer convention, to be held at Chicago, Ill., during Engineers' Week at the World's Fair have been completed. *p. 420–1.* Five of the technical papers to be presented are published in full in this issue; abstracts of all others scheduled for presentation also are included. *p. 412–19*

INSTALLATION and performance of high voltage lightning arresters is reviewed in a report prepared jointly by A.I.E.E. and N.E.L.A. subcommittees. The report was prepared from answers to a questionnaire which was circulated to electric power companies and other organizations in various parts of the United States. *p. 394–400*

Professional Advancement—

A Reappraisal of the Value of Institute Membership

By
J. ALLEN JOHNSON
FELLOW A.I.E.E.
Vice-President, A.I.E.E.
North Eastern District

DURING this period of serious industrial depression some members of the Institute, and of other professional societies as well, have found it necessary or considered it expedient to resign their membership. This has been a misfortune for the Institute and an even greater misfortune, I believe for the individuals concerned. Indications now are that we are passing through the final stages of this depression and that it shortly will be followed by a period of prosperity during which engineers and recent graduates of engineering colleges again will find ready employment in industry.

If this is so, and the normal course of engineering progress is to be resumed, many engineers, and particularly young engineers so situated, undoubtedly will be asking themselves whether they should join or rejoin their professional societies. Therefore, now is an appropriate time to reconsider and reappraise the worth of membership in such professional societies or, in other words, to formulate and try to answer the question, "What is the fundamental basis of the value of membership in a professional society, and how can this value be measured?" It seems probable that the answers to this question will be found in a consideration of the means through which the engineer may best promote his own professional advancement.

Advancement in his profession is surely the legitimate desire of every ambitious engineer. Such advancement normally occurs as he develops his knowledge, his imagination, and his judgment. Knowledge furnishes him with the tools and materials with which he works. Imagination enables him to unite those materials into useful combinations. Judgment enables him to choose wisely among such combinations those which best fulfill the desired purposes. Knowledge is most rapidly extended, imagination most effectively stimulated, and the perspective necessary for sound judgment most surely acquired by observation and study of the thoughts, activities, and accomplishments of others.

The benefits which an engineer derives from his membership in a professional society are principally those which flow from the opportunities which such membership presents for such observation and study of the work of others of his profession. No one can measure these benefits in tangible terms; they have to be taken on faith, but they are none the less real. The truth of this statement is supported by the fact that the great majority of engineers recognized as leaders in their professions will be found to have been members of their appropriate professional societies for many years. All of these will testify that such membership has contributed immensely to their advancement, though none perhaps could say exactly when or how.

Obviously the operation of this principle involves not only the act of receiving, but also, and necessarily, the act of giving, for manifestly none can receive if none gives. The privilege of receiving thus carries with it the obligation of giving. The possession of this spirit of "noblesse oblige" thus is the outstanding identifying characteristic of the truly "professional" engineer.

The measure of the value of membership in a professional society like the American Institute of Electrical Engineers resides in the fact that the potentiality of receiving vastly exceeds that of giving, since the income may be measured in terms of the total membership whereas the outgo is limited to that which the individual himself can give. Thus in a society of 15,000 members the potential advantage of membership to the average member is substantially 15,000 to 1; that is, he may receive freely 15,000 times as much as he himself contributes. Even though all members do not give, and not all that is given can be absorbed by any individual member, in actuality the average ratio easily may be several hundred to one and is limited only by the member's ability or willingness to receive.

Surely a privilege of such potential value should be sought eagerly by every qualified engineer, and once acquired should not lightly be relinquished. The small annual payment required of each member to make the association possible should be quite insignificant compared to the invaluable assistance to his professional advancement thus made available for the taking.

In the decentralization of industry which seems likely to accompany its rehabilitation following the present upheaval, the opportunities for professional contacts among large industrial groups seem likely to be reduced, and the individual engineer thus may be thrown more and more upon his own resources. That he maintain contact with the progress of the art through membership in his professional society seems likely, therefore, to be of even greater importance than in the past.

The American Institute of Electrical Engineers offers many opportunities to electrical engineers for the accumulation of knowledge, the stimulation of imagination, and the acquisition of perspective. Is it not a part of our duty, as beneficiaries of these opportunities, not only to take full advantage of them for ourselves, but to bring them to the attention of others equally qualified to share them?

Opening address of the ninth annual meeting of the A.I.E.E. North Eastern District, Schenectady, N. Y., May 10–12, 1933. *Not published in pamphlet form.*

Air Conditioning of Private Homes

Air conditioning, having already proved its worth in theaters and auditoriums, now is being developed for the home. In this article are discussed equipment and energy requirements for both complete and partial air conditioning of typical homes in various climates. The electrical load that would accrue from a widespread use of this type of equipment also is discussed from the standpoint of the electrical utilities.

By
D. W. McLENEGAN
MEMBER A.I.E.E.

General Elec. Co.,
Schenectady, N. Y.

GROWTH of public interest in air conditioning of homes give rise to questions that will affect the development of this new art. What size and type of equipment are needed to condition the air of an average home? How long are the operating seasons for this equipment? Must the electric utilities enlarge their service facilities to care for the added load? Does this load combine favorably with other domestic electrical loads? This article presents data relating to these questions, based upon climatic conditions in various parts of the country.

Functions of Air Conditioning

Air conditioning includes specifically:

1. Control of air temperature.
2. Control of relative humidity, or moisture content of the air.
3. Supply of fresh air.
4. Cleaning of the air to remove odors and dust.
5. Circulation of the air.

Although air conditioning commonly is associated with the idea of cooling in summer, it includes also heating and humidification in winter, as well as circulation of air and ventilation during all seasons. Development of automatically controlled heating plants has made possible more accurate control of the temperature in heated buildings, as well as more efficient use of fuel.

Regulation of humidity is highly important in promoting human comfort. It is well known that with low outdoor temperatures, the indoor air tends to become extremely dry unless water vapor constantly is added. Although the relation between humidity and health has not been established beyond question, the evidence in many cases points to an improvement in health where proper equipment is installed to maintain a relative humidity of from 40 to 50 per cent in winter. At the same time, the highly humid conditions that frequently prevail in summer, even when the temperature is not extremely high, call for equipment to dehumidify the air. Cooling equipment usually is used for this purpose in addition to its other function of reducing the temperature. The cold surfaces remove some of the moisture from the air, just as a pitcher of cold water in a warm room becomes covered with water condensed out of the surrounding air.

With properly directed air circulation, comfort may be improved by reducing the temperature difference between the breathing level and the floor level, particularly in cold weather when this difference may be as much as 10 deg if the air is not kept in motion.

Table I—Conditions Recommended for House Cooling*

Outside Temperature, Deg F	Dry Bulb Deg F	Wet Bulb Deg F	Effective Temperature, Deg F	Relative Humidity, Per Cent	Grains of Moisture per Lb Dry Air
95	80.0	65.2	73.4	45.0	69.0
90	78.0	64.5	72.2	47.5	69.0
85	76.5	64.0	71.1	50.0	69.0
80	75.0	63.5	70.2	52.5	69.0
75	73.5	63.0	69.3	56.0	69.0
70	72.0	62.5	68.2	60.0	69.0

* Taken from "Guide" of the American Society of Heating and Ventilating Engineers.

The advantages of clean air hardly can be questioned. A properly designed ventilating and cleaning system not only must have capacity adequate to handle several air changes per hour in the occupied room, but also must distribute this air without causing drafts. By properly directing and controlling the circulation of air, stale air and tobacco smoke may be removed; as a by-product, the ventilating equipment can eliminate much of the noise now tolerated in offices ventilated by opening the windows.

Operating Requirements

To determine the operating requirements for air conditioning equipment, temperature charts (Figs. 1 to 3) have been prepared from the weather records of 3 different cities. Maximum temperatures (curves *A*) recorded during the summer months indicate the maximum conditions at which a cooling equipment may be required to operate. Minimum temperatures (curves *E*) for the winter months give an index of the maximum capacity for which heating equipment must be designed. Since all of these curves are based upon the combined records of several years, they may not indicate accurately the heating and cooling loads for any specific year. Curves for Chicago, Ill., are similar to those shown in Fig. 1 for Albany, N. Y.

Full text of a paper presented at the A.I.E.E. North Eastern District meeting, Schenectady, N. Y., May 10–12, 1933. *Not published in pamphlet form.*

The heating season is taken as the period during which the monthly mean temperature is less than 65 deg. For Albany or Chicago this period is approximately $9^1/_2$ months, although actually about 95 per cent of the heating load normally occurs during a 7-month period.

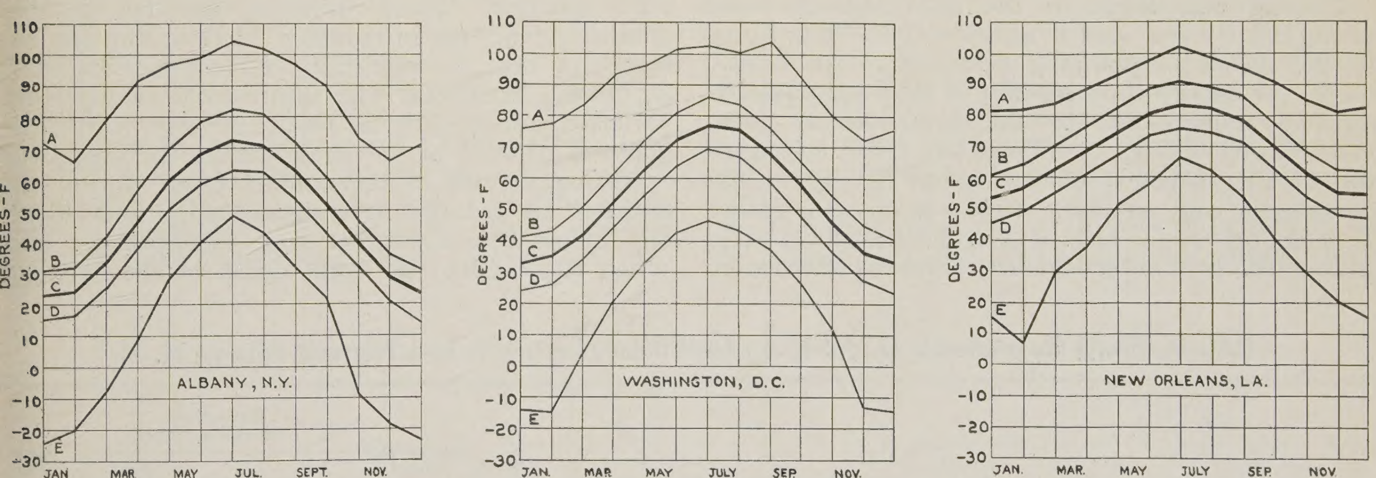
Maximum required heating capacity usually is based upon a temperature 15 deg above the lowest ever recorded; and to provide quick response, the plant is specified to have at least 20 per cent excess capacity. The total heating effect for the season is the summation of the amounts by which the daily mean temperatures fall below 65 deg, and is obtained from the degree-day handbook of the American Gas Association. Since an automatic heating plant operating continuously at full capacity would give a degree-day product equal to the number of days multiplied by the maximum heating capacity, the number of hours operation of such equipment is found by direct proportion, i. e., the actual degree-days divided by the maximum possible degree-days of plant output during the season. This number of hours is based on a 24-hr per day heating requirement.

Operating season for humidifiers has been taken as the time during which the mean outdoor temperature is less than 55 deg. During this period, the total hours is based upon half-time operation over a 12-hr day. Where forced circulation duct systems of warm air heating are used, the operating period for the fan is assumed equal to that of the heating plant, although in some systems the fan runs continuously.

For estimating the cooling season, curve *B* is used, representing the monthly mean temperature plus half of the average daily temperature variation. Since the daily variation is approximately 16 to 18 deg in summer, it is assumed that the temperature will rise 8 or 9 deg above the mean during the daytime and fall about the same amount below the mean during the night. Limits of the cooling seasons are determined by the points where curve *B* crosses the 70-deg line, representing a period of about 4 months for Albany or Chicago, 5 months for Washington, and 8 months for New Orleans. This estimate of the cooling season for Albany and Chicago may be somewhat short of the actual season, since the spring and fall months often bring periods of extremely hot weather which are offset, in the records of monthly mean temperature, by periods cold enough to require house heating. The maximum cooling effect considered desirable is shown in Table I.

The recommendations of Table I may be approximated if the house is cooled by $^1/_2$ the difference between outdoor temperature and 70 deg. It is generally believed, however, that a temperature of more than 82 or 83 deg does not constitute a comfortable condition for continuous occupancy, even when the outdoor temperature is 105 deg or more. For northern cities, a plant that will provide 15 deg of cooling (with suitable control of relative humidity) generally represents the maximum size that is justified, even though this may not be adequate on the occasional 100-deg days. For southern cities, in which this temperature is not uncommon, a cooling capacity of 18 or even 20 deg might be justified.

In determining the number of hours operation of cooling equipment (up to this time, the author has not seen any authoritative analysis of summer cooling requirements for the principal cities, corresponding to the heating data of the American Gas Association's degree-day handbook) it may be assumed that relatively little cooling is needed during the night. There are, of course, exceptions in the case of unusually hot nights, and also in closely built districts where the walls of large buildings give off heat stored during the day. The extent to which cooling is required during the morning is affected considerably by the night temperature, represented by curve *D* in Figs. 1 to 3. If the house is well ventilated during the cooler hours of the night, the rise of indoor temperature may lag several hours behind the rise of outdoor temperature.



Figs. 1, 2, and 3. Climatic temperatures for 3 cities in different localities

A. Maximum ever recorded during month B. Mean C plus $^1/_2$ average daily variation C. Monthly mean temperature D. Mean C minus $^1/_2$ average daily variation E. Minimum ever recorded during month

Typical Equipment

In a house of 8 or 9 rooms, completely air conditioned with modern apparatus, the list of equipment might include:

1. Automatic heating plant.
2. Air distribution system.
3. Kitchen ventilator.
4. Fan type humidifier.
5. Attic ventilator.
6. Refrigerating plant, 5 to 6 tons. (One ton of refrigeration is defined as the removal of heat at the rate of 12,000 Btu per hour.)

Alternatively, the cooling equipment might be restricted to 2 or 3 rooms, the capacity being about 2 tons. The capacity needed in these equipments is related closely to the type of building construction. For a well insulated house with tight doors and windows, both the winter heating and the summer cooling loads will be considerably smaller than those for an uninsulated house of loose construction. Similarly, in a loosely built house, the humidity that can be maintained may have to be held below the optimum value because of the danger of condensation. Of the equipment listed, the air distribution system and the kitchen ventilator would be used throughout the year, and the other equipment for limited seasons which can be estimated from climatic data.

Within reasonable limits, the size of the heating load does not greatly affect the electrical consumption of an automatic heating plant. The rate of fuel burning usually is adjusted to the maximum heating requirement of the building; and since the rating of the electrical equipment does not increase in direct proportion to the capacity of the heating plant, the energy consumption of the electrically driven mechanism is dependent principally on the severity of the weather.

Cooling equipment of the conventional vapor compression type uses a motor driven compressor as the means of pumping heat out of the house; hence the energy consumption of that equipment is directly proportional to the total cooling load. With electric energy at 3 cents per kwhr, a 5- to 6-ton cooling plant, requiring about 10 hp in the compressor and auxiliary drives, involves a rather high energy cost; but by considering the sources from which heat enters the house, means of reducing this load may be suggested thereby bringing the equipment within the reach of a greater number of users. In a 9-room house in Schenectady, N. Y., the cooling load was calculated as follows:

	Btu per Hour
Conduction through walls and windows	15,300
Five people (400 Btu per hour per person)	2,000
Cooking—disregarded since kitchen is ventilated but not cooled	
Lighting—negligible during the day	
Ventilation and dehumidification	12,600
Conduction from attic, where heat accumulates from solar radiation	10,200
Solar radiation on walls and through unshaded windows	26,100
Total	66,200

This load was based upon outdoor conditions of 91 deg F and 45 per cent relative humidity, and indoor conditions of 78 deg F and 49 per cent relative humidity with slightly more than one change of air per hour.

The use of awnings over the windows exposed to the sun reduced the load by 11,000 Btu per hour. Circulation of outdoor air through the attic, preventing the accumulation of heat due to solar radiation further reduced the load by 10,200 Btu per hour, with an expenditure of only 150 watts for the attic ventilating fan. The total cooling load thus was reduced to 45,000 Btu per hour.

An insulating layer in the walls would have reduced further the entrance of heat into the house, bringing the total cooling load down to about 36,000 Btu per hour. A plant of that capacity would require a 5-hp compressor motor and approximately $\frac{1}{2}$ kw of auxiliaries; its initial and operating costs (as well as those of the winter heating plant) would be correspondingly lower, and the market considerably widened. These shielding features provide another advantage in summer, in retarding the entrance of heat by radiation and conduction. For example: In Albany the mean daily temperature variation during July is about 18 deg; with adequate ventilation of the house during the night, the operating periods of the cooling plant during the morning are reduced by wall insulation and shielding, unless the night has been exceptionally hot. When the outdoor air cools again in the evening,

Table II—Energy Requirements of Typical Air Conditioning Equipment for a Home in Albany, N. Y.

Equipment	Typical Electric Load	Watts Input	Approximate Power Factor	Estimated Operating Time: Period	Estimated Operating Time: Total Hours	Kwhr Per Season
Automatic oil burner or furnace	1/8-hp split phase motor; also controls and ignition	200	60%	Sept. 15–May 15	1,880	376
Automatic coal stoker	1/6-hp split phase motor driving stoker mechanism and blower; control devices	250	65%	Sept. 15–May 15	1,880	470
Automatic gas furnace	The majority do not use forced draft; hence electric energy required is negligible					
Air distribution system for heating with ducts	1/4-hp split phase motor with controls	300	70%	Sept. 15–May 15	1,880	564
Humidifier (with motor-driven fan)	Motor (seldom economical to use electric energy to furnish heat)	50	50%	Oct. 1–Apr. 15	2,160	108
Cooling equipment and air distribution:						
A. 2 rooms (1.5 tons)	3 hp total. Capacitor motor used to drive compressor	3,000	90%	May 1–Sept. 15	200	600
B. 8-room house of average construction (4 tons)	7 1/2 hp total. Polyphase motor generally used to drive compressor	7,000	80%	May 1–Sept. 15	200	1,400
Attic ventilating fan	1/10-hp split phase motor	150	55%	May 1–Sept. 15	480	72

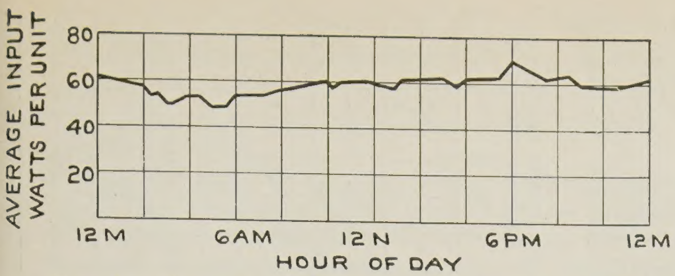


Fig. 4. Average daily load variation of 1,000 domestic electric refrigerators

the heat flow through the house walls is partly reversed, a definite gain is realized from this time lag.

It is evident that the capacity and cost of operating air conditioning equipment are related closely to the type of house construction. When planning new buildings, much may be done to reduce the size of equipment required, its operating cost, and the cost of installation.

Power Requirements

Even among air conditioning equipments of a single type, there is a considerable variation in power requirements. Nevertheless, an average figure may be established for each important class of equipment, to serve as a basis of estimating the energy requirements of such apparatus for the operating season. It is possible also to designate the general types of electric motors that constitute most of this load, and to indicate approximately the power factor at which they operate. Summaries of this type have been prepared for Albany and Washington (Tables II and III). Of course, these data do not represent accurately the energy consumption for any specific make of equipment. In addition, the figures representing hours of operation per season may be misleading unless properly interpreted. With the usual variation in weather conditions, much of the operation is intermittent or at reduced capacity, depending on the design of the equipment. These intermittent or reduced-capacity periods, distributed as needed throughout the operating season, produce comfortable conditions with relatively few equivalent hours of full-capacity operation.

From these same tabulations the load factor of the various devices may be estimated. As regards automatic heating equipment, in Albany the load factor is approximately 33 per cent based upon 8 months; in Washington, 26 per cent based upon $7^1/_2$ months. These values are comparable with the load factor of a domestic refrigerator, and the rate of energy use also is comparable.

The load factor of cooling equipment is somewhat lower. In Washington, for example, the operation of cooling equipment for 335 hr represents a load factor of 9.2 per cent based upon an operating season of 5 months, or 3.8 per cent based upon the whole year; for New Orleans, it is 17 per cent based upon an 8-month operating period, or 11.4 per cent based upon the entire year. However, all these figures are based upon the operation of a single equipment and do not take account of the diversity in a large group of installations. No operating records are available for large groups of house cooling installations; however, Fig. 4 (taken from a curve published by H. A. Snow, Detroit Edison Company, Mich.) shows a daily load factor of 87 per cent for 1,000 domestic electric refrigerators, although the load factor of a single refrigerator is of the order of 30 to 40 per cent. From this it may be assumed that the combined load factor of a large group of house cooling plants also would be somewhat better than that of a single plant. Furthermore, the winter air conditioning equipment involves a total energy use (Table II) nearly as great as that of the summer air conditioning plant, although its maximum demand is much lower. Hence, if the air conditioning plant is considered as a whole, its yearly load factor is substantially higher than it would appear to be at first.

A typical daily load-time chart of winter air conditioning equipment in Albany, based upon the combined records of several installations is shown in Fig. 5; for comparison, a typical load curve* for domestic electric lighting and appliances also is shown. The load imposed by winter air conditioning equipment is fairly uniform throughout the day, except for a peak in the early morning; hence, the

* These curves representing test results on a group of 400 residences, are redrawn from "Residence Load Characteristics Based on Field Studies," by G. L. Jorgensen and R. L. Matteson, *Electrical World*, Nov. 19, 1932.

Table III—Energy Requirements of Typical Air Conditioning Equipment for a Home in Washington, D. C.

Equipment	Typical Electric Load	Watts Input	Approximate Power Factor	Estimated Operating Time: Period	Estimated Operating Time: Total Hours	Kwhr Per Season
Automatic oil burner or furnace	$^1/_8$-hp split phase motor; also controls and ignition	200	60%	Sept. 15–May 1	1,425	285
Automatic coal stoker	$^1/_6$-hp split phase motor driving stoker mechanism and blower; control devices	250	65%	Sept. 15–May 1	1,425	356
Automatic gas furnace	The majority do not use forced draft; hence electric energy requirement is negligible					
Air distribution system for heating with ducts	$^1/_4$-hp split phase motor with controls	300	70%	Sept. 15–May 1	1,425	428
Humidifier (with motor-driven fan)	Motor (seldom economical to use electric energy for heating)	50	50%	Oct. 15–Apr. 15	2,520	126
Cooling equipment and air distribution:						
A. 2 rooms (2 tons)	$3^1/_2$ hp total. Capacitor motor used to drive compressor	3,500	90%	Apr. 15–Sept. 15	335	1,072
B. 8-room house of average construction (4 tons)	9 hp total. Polyphase motor used to drive compressor	8,500	85%	Apr. 15–Sept. 15	335	2,840
Attic ventilating fan	$^1/_8$-hp split phase motor	200	60%	Apr. 15–Sept. 15	750	150

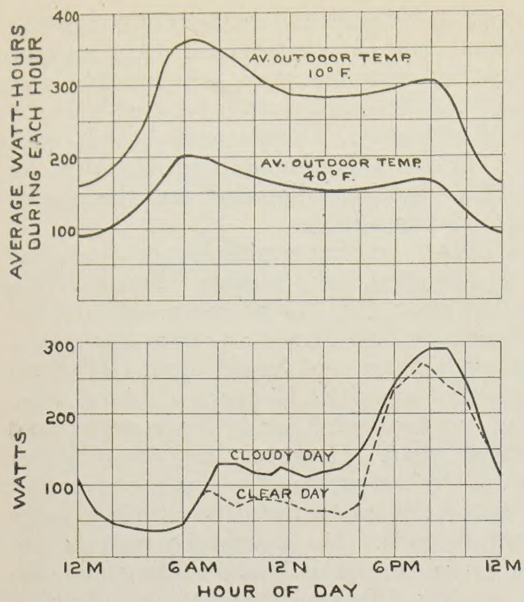


Fig. 5. (Left) Running load 500 watts; includes heating (oil furnace) air circulation, and humidification.

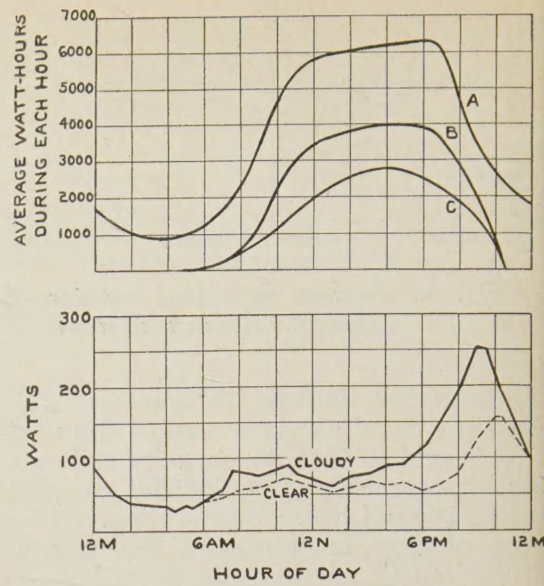
Fig. 6. (Right) Running load 7,000 watts; includes 4-ton cooling plant

A. Clear day, 95 deg F maximum outdoor temperature

B. Clear day, 85 deg F maximum outdoor temperature

C. Cloudy day, 85 deg F maximum outdoor temperature

Winter (left) and summer (right) lighting and small appliance loads



Figs. 5 and 6. Winter (left) and summer (right) air conditioning loads (upper curves) compared with typical domestic electric lighting and small appliance loads (lower curves)

use of such equipment does not aggravate the problem of supplying on-peak load.

As regards summer air conditioning equipment, Fig. 6 shows calculated load-time curves for a 4-ton house cooling plant compared with a typical summer lighting and appliance load.* The curves for air conditioning are only approximate, because their shape depends on assumed weather conditions, house construction, shielding features employed, and conditions of occupancy. Considering residential load only, the cooling load is partly on-peak, as regards the time of day at which it occurs; from the seasonal standpoint, however, it occurs during the time of light loads, both in domestic and commercial use.

Seasonal distribution of air conditioning load is illustrated in Fig. 7, which represents graphically the monthly energy requirements of a domestic air conditioning plant. This chart is based upon the climate of Albany, using the data given in Table II, and is generally applicable for eastern and mid-western cities at about the same latitude.

If the concentration of house cooling plant loads eventually becomes a problem, it may be feasible to provide equipment with storage capacity sufficient to permit shutting down during the period of greatest domestic load. As low temperatures are not used for comfort cooling, ice provides a suitable means of storage; hence, the equipment can be designed to freeze ice during off-peak periods. Carrying the same idea further, the operating periods and the load factor may be increased by using equipment of small capacity and lower demand, with larger storage. During severe hot weather, almost continuous day-and-night operation might be attained. However, for equipments of household and small commercial size, the addition of storage capacity involves an increase in first cost, in spite of the reduction in machine capacity. Hence, it is unlikely that house cooling equipments with storage capacity will be used widely until the incentive of considerably lower operating cost is offered for plants that shut down during the peak load hours.

Commercially manufactured ice has been used successfully in several small and medium capacity installations where the daily and seasonal cooling periods are of short duration. Low initial investment is the principal advantage, the operating cost per day being relatively high. Consideration must

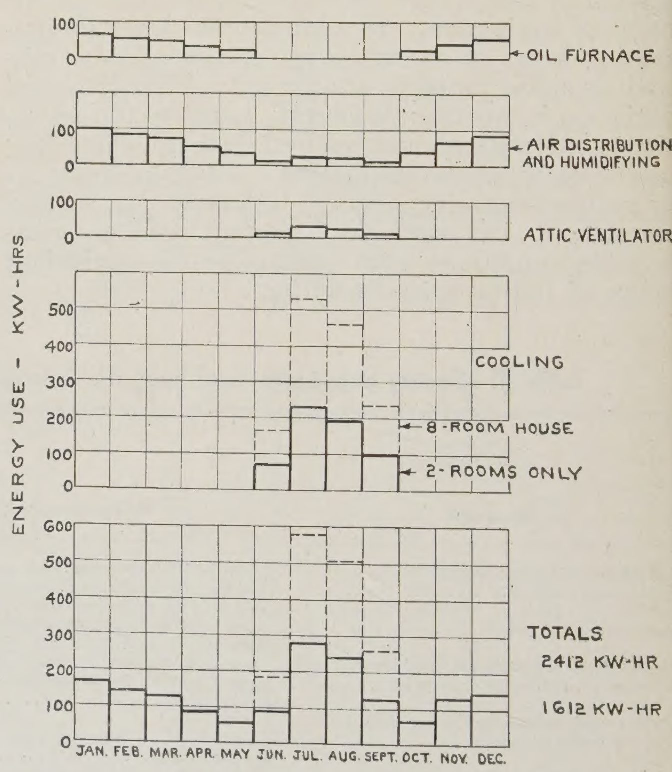


Fig. 7. Summary of energy requirements of air conditioning plant for a typical home in Albany

* These curves representing test results on a group of 400 residences are redrawn from "Residence Load Characteristics Based on Field Studies," by G. L. Jorgensen and R. L. Matteson, *Electrical World*, Nov. 19, 1932.

be given also to the space requirement, the daily attention required in refilling the ice bunkers, and the removal of sediment. The question of "demand charge" also may enter, since the ice requirement is large and variable.

As an alternative to the motor driven compressor, the water-vapor and steam-ejector cooling system justifies consideration in some cases. Given a modern automatic heating plant of the types mentioned earlier in this article, steam at 12 to 15 lb per sq in. pressure may be used as the energy source. Where central plant steam is accessible, the higher pressure available from such a source permits a better thermal economy, which may offset largely the higher unit cost of central plant steam. Power required for auxiliary pumps and fans is relatively small, amounting to approximately $^3/_4$ kw for an equipment of 5-tons cooling capacity. Adding to this the power required by the heating equipment, the electrical input becomes about 1 kw.

The steam-ejector cooling system cannot be applied as generally as the compression system, because it requires not only steam under pressure, but also a large amount of condensing water as compared with a compression refrigerating machine. But where these requirements can be met, a steam-ejector system of 5-ton capacity or larger may compare favorably, both in first cost and in operating cost, with a vapor compression system of equal capacity.

Summary

Briefly, the conclusions of this analysis are:

1. The use of automatic heating and winter air conditioning equipment gives rise to an electrical load that is larger, per unit, than the domestic electric refrigerator load, and which in general, has desirable characteristics.

2. House cooling equipment is available in several types, with varying electrical requirements. The size of equipment required can be reduced materially if suitable house shielding be provided and if the requirements for air conditioning be considered in the design of new buildings.

3. The power demand of a complete house cooling plant is large enough to warrant the installation of a separate polyphase power supply. A plant adequate for 2 rooms generally is within the limits of single phase house distribution service.

4. If the operating cycle of cooling equipment adds unduly to the existing peak of domestic load, equipment designed for off-peak operation may be used, provided savings in operating cost can be realized to offset the increased investment.

5. Without resorting to a cooling plant, considerable improvement in summer comfort may be secured by installing ventilating fans which involve a relatively small first cost and operating cost. For winter use, devices to humidify and circulate the air provide similar advantages.

Accelerated Aging Tests on High Voltage Cable

By
D. W. ROPER
FELLOW A.I.E.E.

Commonwealth Edison Co., Chicago, Ill.

Having found the 66-kv cable installed in 1926 between generating stations to be unsatisfactory, the Commonwealth Edison Company, Chicago, Ill., set about to insure that cable used for similar installations in the future would be of a quality befitting its importance on the system. This object was attained by correlating test results with service records, devising new tests, and determining proper criteria to be used with all tests. From the results of an accelerated aging test, which produces in a short time the same indications of cable deterioration as those resulting from years of service, the stability of cable insulation can be determined without testing to failure.

ASSUMING that satisfactory 66-kv cable could be obtained, the Commonwealth Edison Company, Chicago, Ill., in 1926 adopted a new system plan[1] which included 66-kv underground lines of 60,000-kva carrying capacity that practically constituted a bus extending across the city and sectionalized at the generating stations. The record of failures on this cable, which began shortly after it was placed in operation late in 1926, gave unmistakable evidence (Fig. 1) that this assumption was not entirely warranted; and, further, that there were some marked differences in the quality of the insulation furnished by the different manufacturers. There resulted a great impetus to the investigations[2,3] on cable for lower operating voltages that had been in progress in Chicago for several years.

The object of the investigations forming the basis of this article was to insure that the 66-kv cable secured by the Commonwealth Edison Company for later installations would be of a quality befitting its importance on the system. This object was attained by (1) correlating the results of tests with service

Full text of a paper (No. 33-75) to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933.
1. For all references see bibliography at end of article.

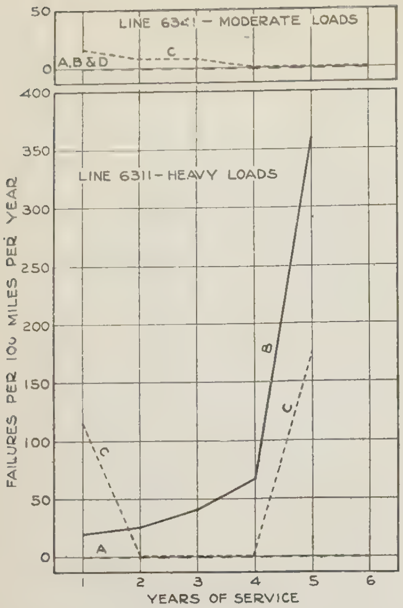


Fig. 1. Rates of failure resulting from defective insulation in 66-kv cable made in 1926

Miles of Cable Installed

Cable	Line 6311
A	4.9
B	5.0
C	4.7
D	0.1
Total	14.7
	Line 6341
A	2.7
B	4.0
C	13.0
D	10.1
Total	29.8

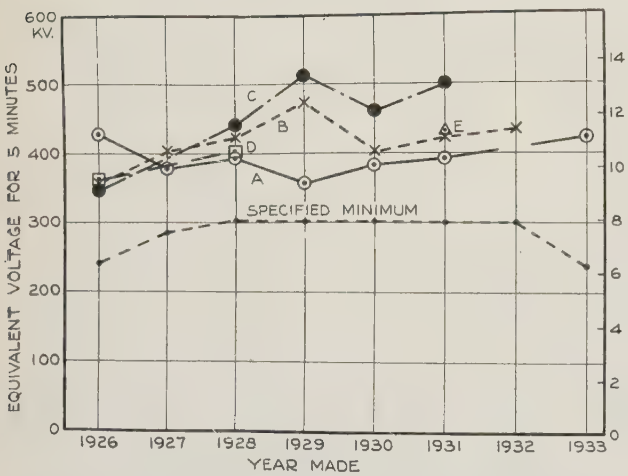


Fig. 2. Averages of results obtained on short-time high voltage tests on new 66-kv cable tested at factories

The method of equating the test results to a voltage that will produce failure in a given time is based on Figs. 6 and 7 of Farmer's paper[6] which indicated the following relation between voltage and time to failure: Voltage $= \frac{\sqrt[n]{\text{Constant}}}{\text{Time}}$. Further investigations by the Electrical Testing Laboratories (New York, N. Y.), Commonwealth Edison Company, and others confirmed this relation and indicated that n should be about 6 for single-conductor cable and 7 for 3-conductor cable. With these values of n, the equivalent periods of time at a convenient value of voltage were calculated for each of the various steps in the actual test and were added. With this result, the equivalent voltage for the given period of time then was calculated in the same manner for the total test

records, (2) devising new tests, and (3) determining proper criteria to be used with all tests so that deficient cable would be eliminated by tests at the factory before shipment.

About 1918, after the large insulation losses[4] of power cables had been made apparent, it became the practice for purchasers to require a measurement of the dielectric loss[5] as a part of the factory tests. The manufacturers, in their endeavors to reduce the dielectric loss of their impregnated paper insulated, lead covered cables gradually abandoned the use of impregnating compounds consisting principally of rosin dissolved in rosin oil or in transil oil, and generally adopted mineral compounds similar to vaseline. A dielectric loss measurement was first included in American specifications about 1919. In the meantime, the change in the type of impregnating compound had resulted in the development of another kind of trouble in the insulation, called "ionization," which may become apparent only after several years of normal service and then is manifested by a rapid increase in cable failures. As a result of this situation, the cable manufacturers in 1924 reduced their guarantee period from 5 years to 2 years. This action eliminated the principal safeguard of the purchasers against cable of inferior quality and rendered necessary a revision of the test requirements included in cable specifications.

An ionization test was first included in American cable specifications in 1924. There followed shortly a considerable improvement in the thoroughness of impregnation, and about the same time the manufacturers changed from grease to heavy oils for their impregnating compounds. These changes were accompanied by a large increase in the dielectric strength (Fig. 2) as determined by the short-time high voltage test. The long-time high voltage test first introduced in 1925 also showed a marked improvement during the next few years in the initial quality of the insulation.

Farmer, in a paper presented at an A.I.E.E. meeting in 1926, described the tests then being applied to impregnated paper insulated cables, their purpose, and their significance. Another paper[3] presented at the same meeting attempted to evaluate the merits of the several tests, and recognized that the specifications were inadequate in that it was possible for cable to pass all the required tests and still prove quite unsatisfactory in service.

Evidence of the difference in quality of the 66-kv cable noted shortly after the cable was placed in service, as well as information which developed later (Fig. 1) may be summarized briefly as follows:

1. Cable A had no insulation failures.

2. Cable B on the heavily loaded line (6311) had a gradual increase in the number of failures for the first 3 years, and then the rate of failures suddenly increased.

3. After several initially defective lengths of cable C on the heavily loaded line had failed and been replaced, this cable gave a perfect record for 3 years; then failures rapidly increased.

4. Cables B and C, which had such an unsatisfactory record on the line with heavy loads, gave much better service on another line (6341) with loads about $^2/_3$ as large.

5. Cable D on the lightly loaded line had no failures. Therefore, it is apparent that (a) insulation may be deficient initially and troubles will develop very quickly after the cable is placed in service; (b) the deficiency may be of a class that will not develop serious trouble for several years; and (c) the insulation may appear very deficient when the cable is required to carry full load every day, but may be satisfactory when moderately loaded for the period covered by this investigation.

Critical Comparison of Test Results and Service Records

Short-Time High Voltage Test. This test is made on a short sample (10 ft long under the lead) that has been subjected to the bending test; it consists

of applying for 5 min an initial voltage nearly twice that applied to each full reel length of cable, and then increasing the voltage in steps until failure occurs.

As shown in Fig. 2, cable A made in 1926 was somewhat better than the other cables, and the test results for all cables were above the specification requirements. Later data in the same figure further indicate that, had the specification requirement been raised to 400 kv, for example, then cable A, which holds the best service record, would have been eliminated in subsequent years. From this information, it may be concluded that:

I. While the short-time high voltage test may be valuable in determining the original quality of the insulation, it is of no value as an indication of the stability of the insulation.

Long-Time High Voltage Test. The long-time high voltage test has been termed an accelerated life test, as it is made by the application of a voltage several times normal to a long sample (75 ft) of cable over a period of hours until the cable fails. As shown in the left side of Fig. 3, this test, made on new cable, gives results that are but little more significant of the stability of the insulation than is the short-time high voltage test.

During the first year of operation of the 66-kv cable, it was discovered by temperature surveys that as a result of local conditions about 2 miles of the heavily loaded line was operating at a higher temperature than the rest of the line, causing the load on the entire line to be limited by the temperature of this portion. During the summer of 1928, all of the 750,000-cir mil cable in that portion of the line was replaced by 1,000,000-cir mil cable; this afforded an opportunity to make tests for determining the relative deterioration of the 4 original cables during their first 20 months of service. The results of the accelerated life tests on these cables shown on the right side of Fig. 3 indicate that, while cable A had undergone no deterioration, cables B and D had deteriorated considerably and cable C somewhat less.

Results of these tests were so interesting that a few lengths of cable from the lighter loaded line were removed solely for the purpose of making similar tests, with results as shown in the middle of Fig. 3. While these data indicate that cable B had undergone some deterioration on the 2 lines, the difference in the deterioration as determined by this test was insufficient to account for the difference in its service record (Fig. 1) on the 2 lines. Cable B removed from line 6341 shows more deterioration than does cable C removed from line 6311; consequently if this test were of value as a measure of insulation deterioration, cable B on line 6341 would have a poorer service record than cable C on line 6311. This, however, is not true, for there have been no insulation failures of cable B on line 6341 (Fig. 1).

From these results it appears that:

II. The long-time high voltage test applied to cables that have been in service is interesting because it gives very different results when applied to cables that when new, were of about the same quality.

III. The test is of considerable value as an indication of the quality of insulation at the beginning of the test, but is of slight value in determining the rate or extent of future deterioration.

IV. Loads to be carried are an important factor in determining the requirements for the cable.

The relative amount of visible evidence of deterioration of cables A, C, and D found on dissection of the samples after test was roughly proportional to the reduction in the time that they withstood the accelerated life test. Cable B showed proportionately much less evidence of deterioration than C and D, but it was the only one that contained rosin; hence:

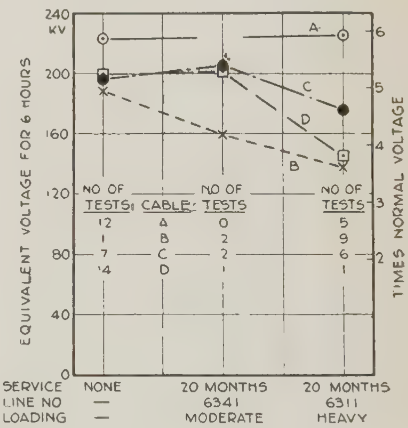
V. The presence of rosin in the impregnating compound will not prevent deterioration of the insulation, but it may restrain or retard the development of visible signs of deterioration.

Dielectric Power Loss. Examination of the records of initial power factor tests on insulation made at the factory on the several 66-kv cables purchased in 1926 and in subsequent years (Fig. 4) indicates no significant differences that can be correlated with the rate of deterioration of the several cables. The records in recent years show less variation in dielectric loss at the maximum operating temperature. This loss is now so low that all chance of dielectric loss failures[2] is eliminated, unless the loss materially increases in service.

By examining the records of sections of cable removed from time to time from the 2 lines under discussion (Fig. 5) interesting information is obtained on increase of power factor of cables in service.

Fig. 3. Averages of results obtained on long-time high voltage tests on 66-kv cable made in 1926; cable tested at factories and in Chicago

Equivalent voltages calculated as stated in subcaption for Fig. 2



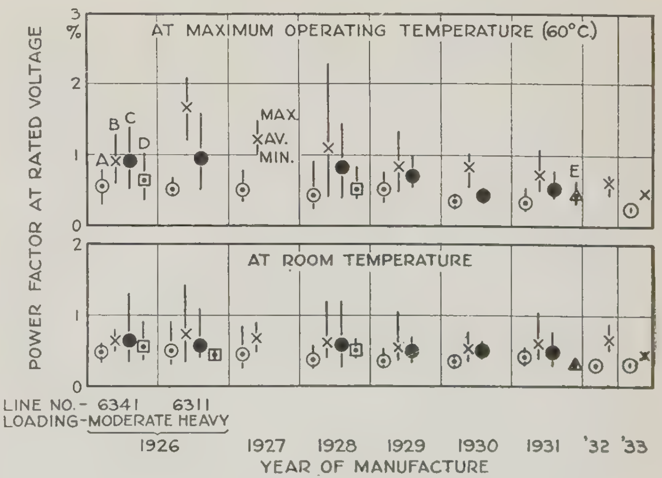


Fig. 4. Power factors of new 66-kv cable tested at factories

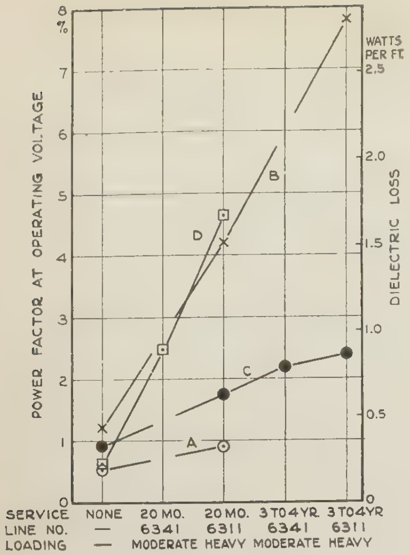


Fig. 5. Average power factors at 60 deg C of 66-kv cable made in 1926

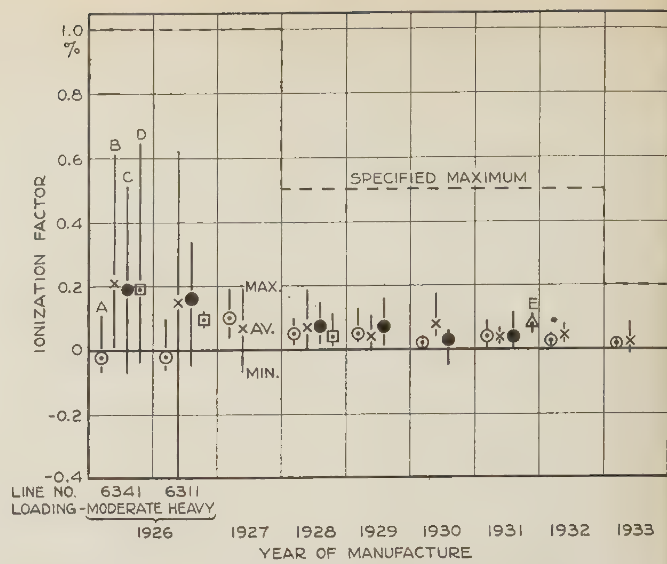


Fig. 6. Ionization factors of new 66-kv cable

Measurements made at factories at 40 and 200 per cent normal voltage at room temperature. Some of the negative values are probably erroneous. Only 2 lengths of cable *D* were on line 6311

Cable *A* shows a slight increase, but even the increased loss (about 0.3 watt per foot) is very low; cables *B* and *D* show the highest increase; cable *C* shows a smaller increase and only a slight difference in deterioration on the 2 lines. However, cable *C* had widely differing service records on the 2 lines (Fig. 1). Cable *D* shows an increase in power factor as great as *B*, and neither has had any service failures on the moderately loaded line.

These results appear to warrant further conclusions:

VI. Two distinct forms of deterioration with service may occur: (1) deterioration which is manifested only by an increase in dielectric loss; and (2) deterioration which results not only in an increase in dielectric loss, but also is accompanied by an increase in service failures.

VII. Initial power factor measurements give no significant prediction of the rate of deterioration in service.

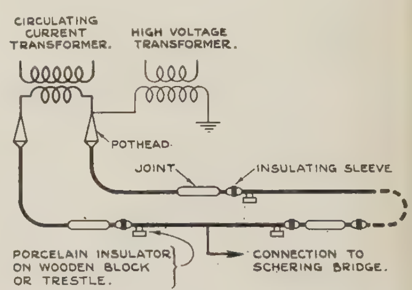
Since the increase in dielectric loss of cable *D*, as shown in Fig. 5, means that the dielectric loss increased from 2 per cent to 7 per cent of the total annual charges, it would be economical to pay 15 per cent more for this cable if the dielectric loss remained constant at the initial value throughout the life of the cable.

Ionization Tests. Tests are made at the factory on each length of cable to determine the ionization factor, i. e., the increase in power factor between 20 and 100 volts per mil of insulation. Test results (Fig. 6) show that cable *A* of 1926, which has had no insulation failure to date, had a much lower ionization factor than the other cables, and that cable *B* had a higher ionization factor than cable *C*. If the failures of cable *C*, due to initially defective insulation (Fig. 1) are eliminated from consideration, it is found that the relative magnitudes of the ionization factors of the 1926 cable on line 6311 give a significant indication of the relative rates of deterioration leading to failures in service.

This statement is confirmed by the record of 66-kv cable installed subsequent to 1926 since, if 5 failures in 1930 which occurred a few weeks after the cable was installed (thus indicating initially defective insulation) are eliminated from consideration, the 3 remaining insulation failures are equal to about one failure per 300 miles of cable per year of service—a highly satisfactory record. All of this cable had ionization factors of less than 0.2 of one per cent.

Fig. 7. Circuit diagram for accelerated aging tests

Two to 10 cable samples were connected in series. Pothead leads were not considered samples under test



These data show that:

VIII. The ionization factor for cable which is to carry full load daily should be less than 0.2 of one per cent in order to insure a satisfactory service record.

If, now, the ionization factors of the cables on the 2 lines installed in 1926 are compared, it will be noted that:

IX. While an ionization factor less than 0.2 of one per cent appears necessary to insure satisfactory cable on a heavily loaded line, a higher ionization factor may be satisfactory if the cable regularly carries only moderate loads.

Accelerated Aging Tests

Since all of the tests had failed to give any significant indication of insulation stability, investigations were started for the purpose of devising a test which when applied to new cable would duplicate within a limited time the deterioration in all grades of insulation that had been noted on cables in service. Several cable manufacturers in private conference some years earlier had suggested that the suitability of impregnated paper insulation for the higher voltages be determined by subjecting the cable to excess

voltage with superposed loading cycles, and taking measurements of the power factor at intervals. Accordingly, after it had been determined that the loading of the 66-kv cable was an important factor in its deterioration, a series of high voltage tests with superposed loading cycles was made on short lengths of cable. All of these tests were made on 750,000-cir mil single-conductor lead-covered cable with 750 mils of impregnated paper insulation.

Test Conditions. Twenty-one samples, from 25 to 50 ft long, were tested by connecting several samples in series (Fig. 7) with insulating joints in their lead sheaths to exclude the joints and potheads from the measurements on the cable. The joints were made especially to prevent the movement of gas or compound into or out of the cable samples. Tests were made at various voltages from 1.5 to 3 times normal and lasted from 2 to 84 days. Heating cycles were obtained by (1) circulating current through the conductor and cooling with water through a jacket around the cable, (2) submerging the cable in oil and heating and cooling the oil, and (3) circulating current through the conductor with the cable in air, with and without current in the lead sheaths. Minimum cable temperature was room temperature while the maximum ranged from 50 to 85 deg C, i. e., from 10 deg below to 25 deg above the maximum permissible operating temperature of 60 deg C. Testing facilities were provided for measuring the power factor of any sample at any portion of the heating cycle without interrupting the current in the conductor. The longest continuous application of the voltage was 18 days.

Two samples, each 1,000 ft long, were tested also in the field laboratory (see Figs. 28 and 29 of reference 7) where they were installed in a standard conduit. These cables were connected to a bus which in turn was connected to one conductor of a 132-kv overhead transmission line, so that the cables were subjected to all the transient voltages caused by lightning and switching. The load on these cables was carried through successive cycles as in the tests on short cable samples, independent of the load on the transmission line. Copper temperatures of these samples were varied up to a maximum of 60 deg C. Facilities were available for measuring power factor and ionization factor.

Observations. Failures in cable of the lower grade usually were preceded by local heating; since the development of local heating is restrained or retarded when the cable is immersed in oil or water, cables tested in air gave results which best correlated with service records. With the cable in air and with double normal voltage continuously applied, about 125 per cent of maximum rated line current was required to heat the conductor to 60 deg C in 5 hr.

Tests at 1.5 times normal voltage required too long to develop definite results, and failed to exclude cables 4 and 5 (Figs. 8 and 9) which from operating records were known to be unsatisfactory. However, tests at twice normal voltage developed within a few days a marked difference in the results on 2 cables (Fig. 10) which had but a moderate difference in ionization factor and which had shown practically the same results in the long-time high voltage test (note IX ante). Tests at 3 times normal voltage failed to correlate with service records.

Significant results were obtained in the tests on short samples, from measurements of power factor at minimum and maximum temperature of each loading cycle and from measurements of ionization factor at less frequent intervals. It was noted that in the lower-grade cable large increases in dielectric loss sometimes varying over a wide range may develop during the tests, but failure may not ensue for a long period. Failures of high-grade cable with low dielectric loss may develop so rapidly that no marked increase in power factor will be noted unless the measurements are practically continuous. All failures except one occurred during the cooling portion of the loading cycle. The one exception noted was the failure of one of the 1,000-ft lengths

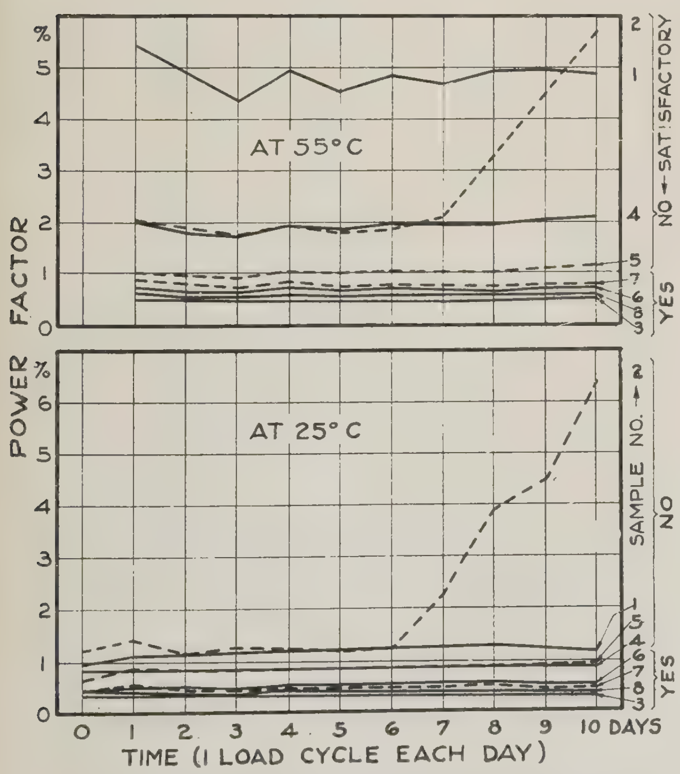


Fig. 8. Power factors of 66-kv cables during first 10 load cycles at 57 kv

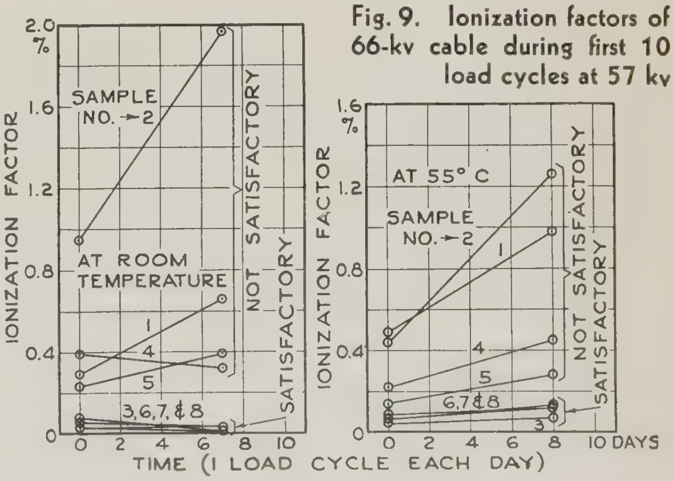


Fig. 9. Ionization factors of 66-kv cable during first 10 load cycles at 57 kv

which occurred after the cable had reached minimum temperature.

Some interesting observations were made on the 2 1,000-ft lengths, these cables being practically identical as determined by all other tests. Cable A failed after operating one month at double voltage and without load, 2 months with loading cycles resulting in a maximum temperature 46 deg C or less, and 6 additional months with loading cycles up to 60 deg C. Cable E failed after operating one month without load, and 2 months with loading cycles up to a maximum temperature of 37 deg C. Both cables showed about the same moderate amount of visible evidence of deterioration in the insulation. Cable A showed an increase in power factor at 20 deg C and test voltage, from 0.3 per cent to 0.5 per cent; and an increase in ionization factor at 20 deg C from 0.02 to 0.06 per cent. Cable E showed an increase from 0.3 per cent to 0.39 per cent in power factor, and in ionization factor at 20 deg C from 0.005 to 0.06 per cent.

Satisfactory cable upon examination showed no visible signs of deterioration at double normal voltage after tests ranging from 2 to 9 months (Fig. 11);

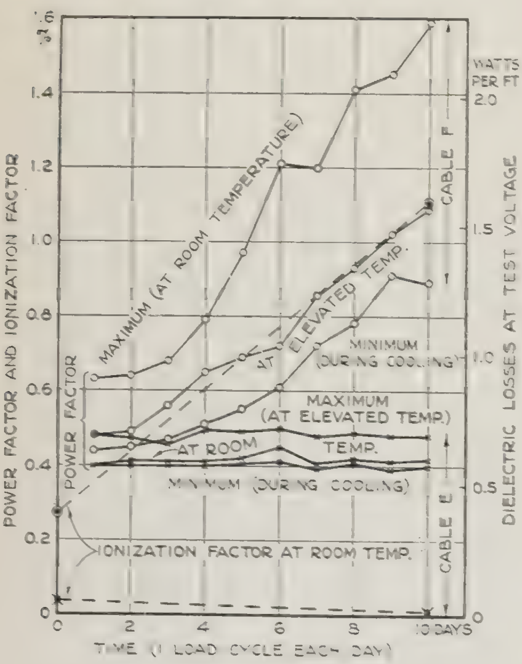


Fig. 10. (Left) Results of accelerated aging test at double normal voltage (76 kv) with load cycles raising cable temperature to 63 deg C

Special samples were furnished for these tests. Results of long-time high voltage tests for cables E and F were equivalent to 276 kv and 284 kv, respectively, for 6 hr calculated as per subcaption of Fig. 2. No operating experience is available for cable F

unsatisfactory cable F (Fig. 10) showed considerable evidence of deterioration after 10 days. Recuperation of the insulation usually was noted with long interruptions of the voltage, and was greater for the lower-grade cable.

Conclusions

Summarized briefly the conclusions reached as a result of the accelerated aging tests are as follows:

X. Accelerated aging tests on 50-ft samples of 66-kv cable at double normal voltage and with superposed daily loading cycles resulting in a maximum copper temperature of 60 deg C will develop in a few weeks, in cables of all grades tested, about the same indications of deterioration as are found in the same cables after years of service.

XI. The criterion of quality is the stability of the insulation during the accelerated aging test; there must be practically no deterioration of the insulation, that is, (1) no significant increase of power factor at maximum and minimum temperatures; (2) no significant increase in ionization factor at room temperature; and (3) no visible signs of deterioration of insulation upon dissection after completion of the test. Tests to failure are unnecessary.

XII. Better information regarding the quality of cable is obtained by testing several sections, each 50 ft long, than would be obtained by testing several times as much cable in one length.

XIII. Improvements in the manufacture of impregnated paper insulation of the ordinary type in recent years has made it possible to secure insulation for operation at 66-kv that gives very satisfactory service.

Suggestions for Further Investigation

Further investigations may indicate the possibility of using somewhat higher voltage than double normal in the accelerated aging test, in order to shorten the time of the test and make it less expensive. With the inclusion of the accelerated aging test in the specifications, it may be possible to eliminate several tests, now included therein, without materially increasing the total cost of testing.

During the past few years, in which the accelerated aging test has been practically in effect in Chicago, the only cable failures that have occurred apparently have resulted from local deficiencies in the insulation which cannot be detected by any known test. These defective lengths have amounted to about 0.3 of one per cent of the number of lengths installed; but, when it comes to lead sheath troubles, as Kipling would say, that is another story.

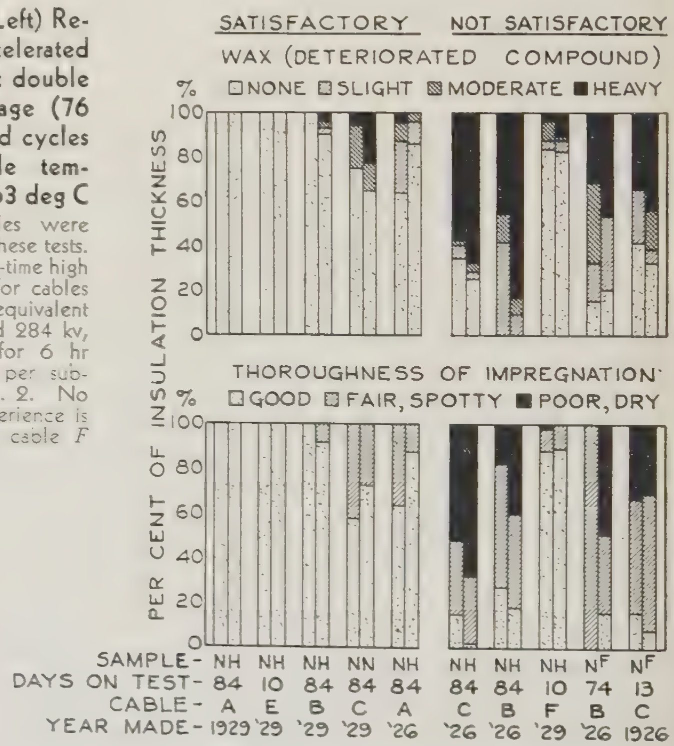


Fig. 11. Deterioration found upon examination of cable after accelerated aging tests; results arranged in order of quality as determined from all information, best sample on left

F. At failure H. Hottest portion N. Normal portion
No dendritic designs were found except at failures

BIBLIOGRAPHY

1. SYSTEM CONNECTIONS AND INTERCONNECTIONS IN CHICAGO DISTRICT, G. M. Armbrust and T. G. LeClair. A.I.E.E. TRANS., v. 49, 1930, p. 582.

2. DIELECTRIC LOSSES AND STRESSES IN RELATION TO CABLE FAILURES, D. W. Roper. A.I.E.E. TRANS., v. 41, 1922, p. 547.

3. THE QUALITY RATING OF HIGH TENSION CABLE WITH IMPREGNATED PAPER INSULATION, D. W. Roper and Herman Halperin. A.I.E.E. TRANS., v. 45, 1926, p. 528.

4. THE INFLUENCE OF DIELECTRIC LOSSES ON THE RATING OF HIGH TENSION, UNDERGROUND CABLES, A. F. Bang and H. C. Louis. A.I.E.E. TRANS., v. 36, 1917, p. 431.

5. MEASUREMENT OF POWER LOSS IN DIELECTRICS OF THREE-CONDUCTOR HIGH-TENSION CABLES, F. M. Farmer. A.I.E.E. TRANS., v. 37, 1918, p. 221.

6. TESTS OF PAPER INSULATED, HIGH TENSION CABLE, F. M. Farmer. A.I.E.E. TRANS., v. 45, 1926, p. 553.

7. ECONOMICS OF HIGH VOLTAGE CABLE, D. W. Roper. A.I.E.E. TRANS., v. 50, 1931, p. 1399.

Beauharnois Development of the St. Lawrence River

Development of the power resources of that portion of the St. Lawrence River which forms part of the boundary between the United States and Canada, for many years has been studied by engineers and talked by politicians; and neither the end of the discussion nor the start of construction is yet in sight. Equal in magnitude of power output, but not of expenditure, is the Beauharnois development of the Soulanges section of this same river, a wholly Canadian enterprise the initial installation of which is now in operation. The power canal of this development will form an integral part of the proposed St. Lawrence waterway. This article describes the project as a whole in a general way and presents in more detail the principal features of the electrical installation.

By
W. S. LEE
PAST-PRESIDENT A.I.E.E.
Consulting Engineer and President, W. S. Lee Engg. Corp., Charlotte, N. C.

THE FIRST SECTION of the Beauharnois hydroelectric development, which has been under construction for the past 3 years, was placed in operation on October 1, 1932, by the Beauharnois (Province of Quebec, Can.) Light, Heat and Power Company, Ltd. The power station is located less than 25 miles from the city of Montreal; when completed it probably will be the largest hydroelectric station in the world as provision is made for an ultimate installation in generating capacity of 2,000,000 hp in the one station to be operated as a single unit.

The layout, design, and construction of this development is based upon step by step construction as needed to meet the power demand, thus keeping the initial expenditure at a reasonable figure, but allowing additional steps to be constructed with a minimum cost and without interfering in any way with the equipment previously installed. A unique feature of this development is that nothing was sacrificed by the adoption of step by step construction; the overall efficiency will be as high and the total capital investment will be as low as if the ultimate installation had been constructed in one operation.

Dikes for the power canal are built for full canal width; as additional water diversion is required, additional excavation will be carried on by hydraulic dredges driven electrically from power which the station itself will generate. This canal will be an integral part of the proposed St. Lawrence Waterway. The power house for the ultimate installation will be one continuous structure approximately 3,000 ft long, with one centralized point of control. The forebay will be common to the entire station, but the tailrace will be constructed in 3 sections with the spaces between tailrace sections utilized for the switching and transmission structures necessary for handling this enormous amount of power. Exceedingly careful study and cooperation was required to balance properly the hydraulic and electrical design for this feature. The 3 divisions of the tailrace enables one or 2 of them to be operated while the other is being excavated and also saves the additional cost of cofferdamming for unwatering purposes.

When complete utilization is made of the available stream flow, the development will be a complete unit, but by the adoption of the step by step construction a very efficient initial installation was secured. The initial financing required was, of course, much less than would have been required for completion of the development in one operation.

Full text of a paper (No. 33-62) to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26-30, 1933.

Exterior view of present power house (1/3 of the ultimate) before construction was completed

Site Near an Industrial Area

Between Lake St. Francis and Lake St. Louis the St. Lawrence River has a fall of 83 ft in an air line distance of approximately 15 miles. The flow of this river is unusually uniform, the average mean flow being 220,000 cfs; maximum and minimum recorded flows in the past 70 years are, respectively, 318,000 and 173,000 cfs. Utilization of the whole mean flow represents a possible ultimate of 2,000,000 hp which can be developed at the one site at Beauharnois.

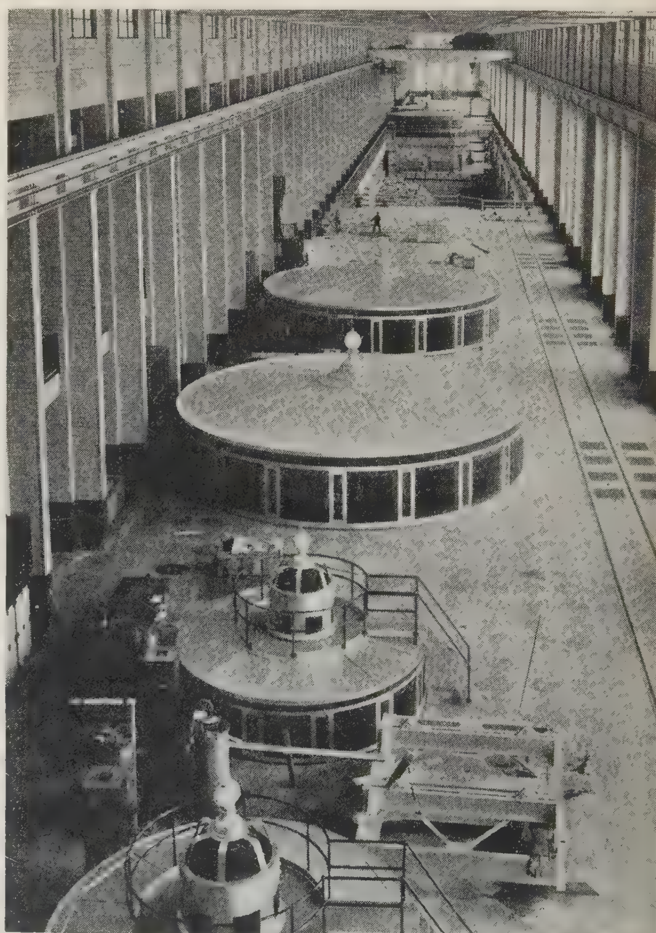
The development consists of a diversion canal between the 2 lakes with the power plant at the Lake St. Louis end. The diversion canal follows closely the route proposed for a navigation canal by the various international joint commissions; the Canadian government has reserved the right for such use and to construct the necessary locks between the canal and Lake St. Louis. Included in the power company's agreement with the Canadian government is a provision for the construction of control works at the head of Coteau Rapids to regulate flow and to maintain the level of Lake St. Francis. The power station is situated within 25 miles of the city of Montreal and is within convenient transmission distance of a great industrial area.

Canal

The canal is 15.5 miles long and extends across the relatively flat country between Lake St. Francis and Lake St. Louis. Much of the canal area is below the level of the upper lake; consequently the canal is carried between dikes for its entire length. At the Lake St. Francis end the dikes are low, increasing gradually to a maximum height of 45 ft in the vicinity of the power house forebay. The dikes are built for a channel width of 3,000 ft to take care of the ultimate diversion of 220,000 cfs. For the initial installation only part of the ultimate channel is excavated below ground line; as additional water diversion is required, the channel will be dredged accordingly. The canal is designed for a maximum water velocity of 2.25 ft per second.

Power Station

While the canal excavation was chiefly in marine clay, with the exception of approximately one mile of boulder clay, the presence of a rock ledge approximately 1,000 ft wide served as an excellent foundation for the power house structure although it required that the tailrace channels be excavated from solid rock. The forebay will be common to the entire station, the north dike being so designed and located as to require minimum change for power house extension. Three independent tailraces will be provided each serving 1/3 of the ultimate development. This not only allows the tailraces to be constructed one at a time as required, without interference with prior construction, but also provides adequate areas between tailraces for switching and transmission structures for the outgoing power circuits.



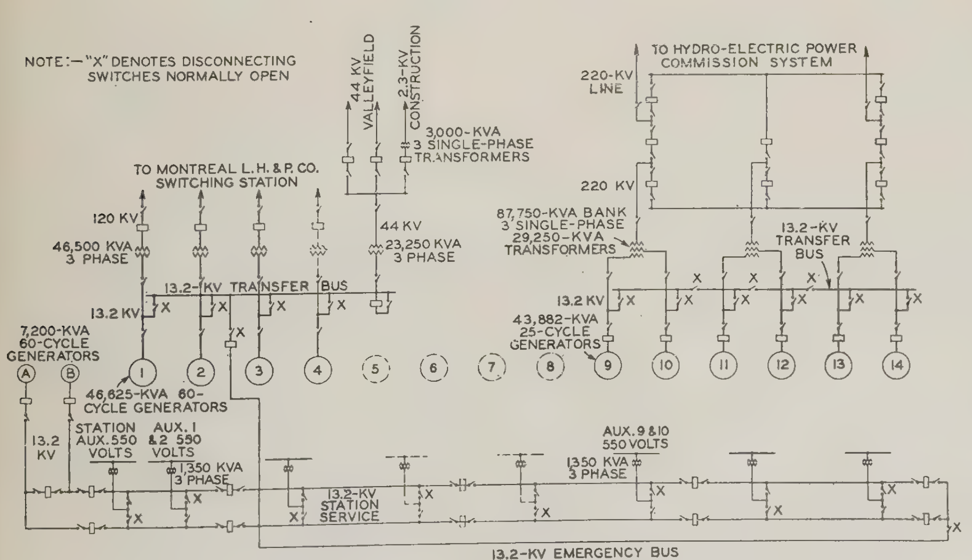
Interior view of the power house before construction was completed

Steel work of the 220-kv switching station may be seen near the far end of the bridge over the tailrace

The present power house, approximately 1,100 ft in length, is designed for 14 50,000-hp generating units and 2 7,800-hp station service units, and is capable of extension for the maximum of 42 50,000-hp units required for utilization of the entire mean river flow. Two 7,800-hp 60-cycle service units, 2 50,000-hp 60-cycle main units, and 2 50,000-hp 25-cycle main units are now in operation. To meet present power contract requirements 2 additional 50,000-hp 60-cycle units and 4 additional 50,000-hp 25-cycle units are to be installed prior to October, 1937. This leaves space available for 4 more units to meet additional power requirements without extending the present power house. At present sluiceways are installed in the space for 2 units to permit by-passing water if found desirable. In order to tie in the power house structure with the north dike, it was found advantageous to extend the bulkhead structure for 4 units beyond the end of the present power house.

On the el-94.0 floor are the governors and governing equipment, water and oil supply pumps, oil filtration and storage system, space for repairing mechanical and electrical equipment, machine shop, and storage space. This floor is the main mechanical operating floor of the station, all control and indicating equipment for such operation being under the direct supervision of the turbine operators. Between the generator piers and the downstream wall is a continuous gallery of sufficient width for a 10-ton truck to traverse the length of the station, thus affording facilities for quick and convenient movement of small repair parts and other equipment. On the el-115.0 floor are the generators, motor driven exciters, generator circuit breakers, and instrument transformers used for indicating the generator output. Suspended below the el-133.0 floor are the 13.2-kv power transfer buses. On the el-133.0 floor are the individual control switchboards for each generator, metering switchboards, 550-volt auxiliary cubicles and the 13.2-kv breakers which connect into the auxiliary ring bus suspended below the el-149.5 floor. A conduit tunnel (floor el-133.0) 12 ft wide and 20 ft high extends the length of the station and connects with the conduit room below the control room and also with the conduit tunnels extending to the various switching stations. A pipe gallery (el-149.5) is provided for all piping and connections to the water and oil supply systems for the power transformers. On the bulkhead are situated the gantry cranes operating the headgates, all power transformers, and the 120-kv transformer circuit breakers. Disconnecting switches are installed on steelwork on the power house roof for isolation of station equipment.

At the east end of the power house a service building is built as an integral part of the power house structure. A lobby, superintendent's office and general offices are situated on the generator floor level (el 115.0). On the el-133.0 floor, space is provided for laboratories, meter testing, and other service requirements. The el-146.0 floor connects with the conduit tunnel and is used for making all control connections to the master control equipment on the el-159.0 floor. Battery charging sets and batteries for the 48- and 250-volt control circuits also are installed on the el-146.0 floor. On the el-159.0 floor are the master control switchboards for the station, and the chief opera-



Schematic wiring diagram for 2 auxiliary and 10 main generating units

General plan of Beauharnois power development

tor's office. The layout is such that the maximum station installation of 2,000,000 hp can be controlled from this one control room.

General Electrical Layout

In considering the electrical layout for this station, it was realized that the units must be operated in independent groups corresponding to the requirements of the customers, but at the same time the requisite flexibility for maximum economic use of the installed equipment must be secured. One of the accompanying illustrations indicates schematically the wiring adopted for the first group of units.

For delivery of 60-cycle-power at 120-kv to the Montreal Light, Heat and Power consolidated the use of a generator with a 3-phase step-up transformer as a unit proved most economic, no generator breakers being provided. A 13.2-kv transfer bus is installed for transfer purposes but will not be used for paralleling generating units. To supply 60-cycle power at 44 kv for construction purposes and local industrial load, a 23,250-kva transformer is fed at present from the transfer bus.

For delivery of 25-cycle power at 220-kv to the Hydro-Electric Power Commission system, a scheme was adopted involving 2 generators each feeding into an independent low voltage "delta" of a step-up transformer bank having a capacity corresponding to 2 generators. The high voltage bus arrangement is of the modified ring type.

For the auxiliary system, 2 generators, each of capacity sufficient to carry the entire auxiliary load, feed into a 13.2-kv ring bus. At the extreme end of the ring a connection is provided to the 60-cycle transfer bus for emergency operation from any 60-cycle main generator. Transfer switches also are provided so that in the event of failure of any ring section, the auxiliary transformer operating from the defective section can be switched temporarily to the opposite ring section until normal ring closure is secured.

Essential auxiliaries for each group of 2 main units are fed from a 3-phase 1,350-kva transformer, energized from an independent section of the auxiliary bus and stepping down from 13,200 to 550 volts. A transformer bank of the same rating is provided for general station auxiliaries. Circuit breakers controlling the auxiliary equipment are housed in steel cubicles on the mezzanine floor of the station (el 133.0) and are operated from the turbine operator's control and signal panels situated adjacent to the governor stands on the el-94.0 floor.

Main Generating Equipment

Main generating units each consist of a 75-rpm 37,300-kw generator direct connected to a 53,000-hp Francis type turbine. The 60-cycle units are rated 46,625 kva at 80-per cent power factor, 13,200 volts, 55 deg C rise; the corresponding 25-cycle units are rated 43,882 kva at 85-per cent power factor, 13,200 volts, 55 deg C rise. The 25- and 60-cycle units are identical in external appearance; they have an outside diameter of 40 ft and a height from floor line to base of signal lamp fixture of 10 ft. Both 25- and 60-cycle units are capable of continuous operation at 14,520 volts at full rated kva. To insure stability, a rotor WR^2 of 110,000,000 (moment of inertia about its own axis in lb-ft^2) was specified for both 25- and 60-cycle units, together with a short circuit ratio of 1.00 for the 60-cycle units and 1.25 for the 25-cycle units. The higher short circuit ratio for the 25-cycle units was required because the units feed into the extensive 220-kv network of the Hydro-Electric Power Commission. The generators are provided with 2 independent windings per phase, current transformers for the relaying system being

installed in each end of each winding. To simplify terminal connections, these current transformers are mounted inside of the generator frame where ample space is available.

The weight of the rotating element plus the hydraulic thrust is carried by a thrust bearing below the rotor. This arrangement reduced the generator weight and height, and facilitates dismantling the unit as the rotor can be lifted from the generator shaft without dismantling the thrust bearing. Guide bearings are provided above and below the rotor, and an adjustable lignum-vitae guide bearing is provided for the runner. A complete unit oiling system is provided for each generating unit.

Governor stands are situated on the operating floor (el 94.0) in close proximity to the servo-motors and all governing equipment, all of which is arranged in right and left pairs between each group of 2 units. The mechanical and electrical equipment is so installed that 2 generating units constitute a complete 100,000-hp unit that can be operated as a separate and independent station.

Station Service Generating Equipment

The 2 station service units each consist of an 180-rpm, 60-cycle generator rated 5,760 kw, 7,200 kva at 80-per cent power factor, 13,200 volts, 55 deg C rise, direct connected to a 7,800-hp Francis type turbine. The general layout is similar to that of the main units except that the conventional design of generator is used with the thrust bearing above the rotor. The generators are provided with direct connected exciters. Generator windings consist of a single circuit per phase with a current transformer installed in each end of each winding; these transformers are mounted inside of the generator frame.

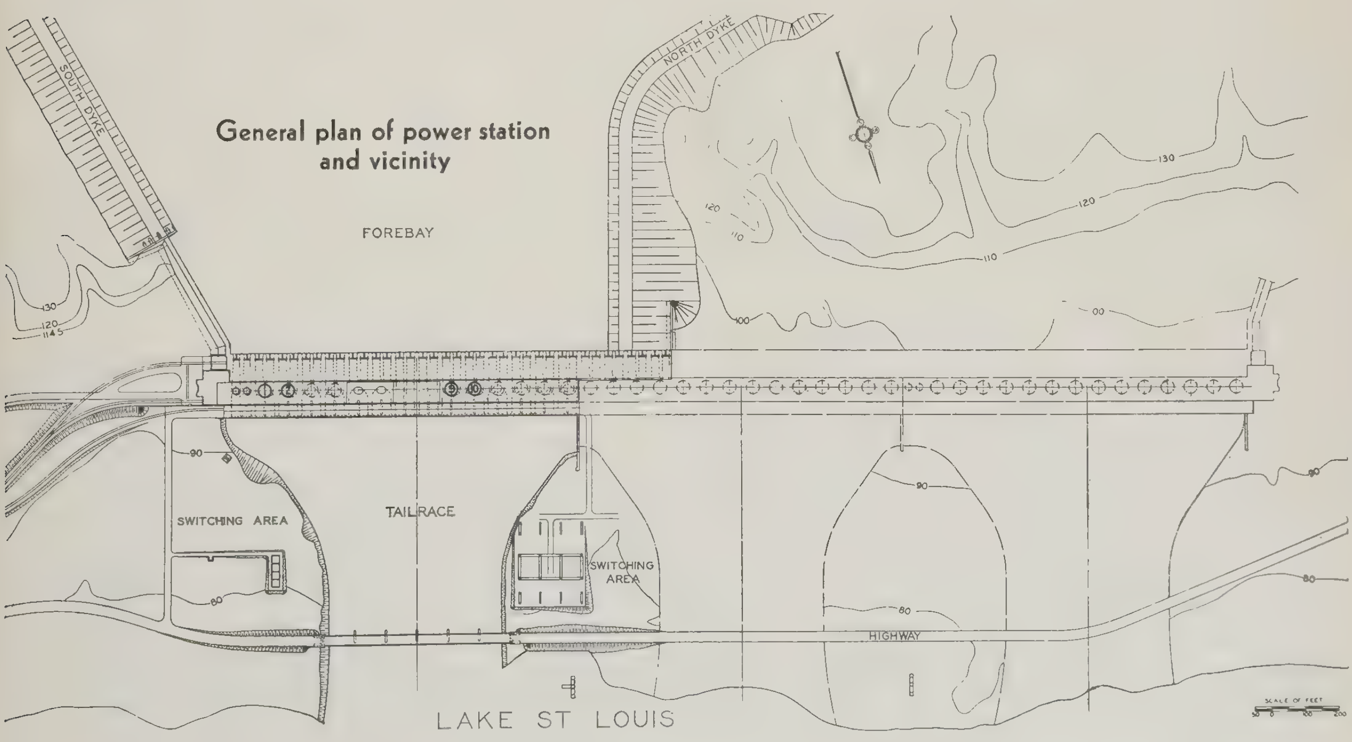
Excitation System

Each main generator is provided with an individual 3-unit motor-driven exciter set consisting of a 320-kw 250-volt shunt-wound separately excited d-c generator, a 4-kw 250/250-volt compound-wound sub-exciter, and a 1,200-rpm 550-volt line start squirrel-cage induction motor. To reduce the length of field leads to a minimum, as well as to allow crane handling, the exciter sets are located on the generator floor adjacent to the corresponding generators. To facilitate replacing a defective exciter set with a spare, the bottoms of the set bases are planed and are supported on planed H-beams set in concrete. With this arrangement a spare exciter unit can be set in place without the time delay incident to alignment. Exciter sets for the 25- and 60-cycle generators are identical. An individual voltage regulator operated by a torque motor in conjunction with a bridge type rheostat in the exciter field provides high speed excitation for each main generator. The excitation system is designed for a rate of response of 200 volts per second and for a stable exciter voltage range from residual voltage to the ceiling voltage of 300 volts.

The direct connected exciter on each of the station service generating units is controlled by a voltage regulator of the same type as those installed for the main units, except for the omission of the high speed contactors; this regulator is used in conjunction with a motor operated rheostat in the exciter field. As the 2 service units operate in parallel, cross compensation is provided.

Power Transformers

All power transformers are located on the bulkhead in the space corresponding to their generating



equipment, thus reducing the low voltage bus length to a minimum. Transfer cars and tracks are provided on the bulkhead; by using the gantry crane, the transformers can be lowered to a similar transfer equipment at ground elevation (115.0) and thence brought into the power house where a repair pit is provided. A complete oil pump, filter press, and storage and piping system is provided so that the transformer oil can be drained, filtered, or replaced conveniently. Water supply pumps are in duplicate, 550-volt power for the driving motors being taken from separate auxiliary transformer banks.

For delivery of 25-cycle power at 220 kv, 3 single-phase water-cooled transformers are used, each rated 29,250 kva, 50 deg C rise; they are Δ-connected on the low voltage side and star-connected on the high voltage side to transform from 13.2 to 218 kv, these rated voltages being based upon full rated kva at 85 per cent power factor. Each transformer has 2 low voltage windings each of $^1/_2$ rated transformer capacity; that is, the bank has 2 independent low voltage Δ-connected windings each of which is connected to an independent generator. As the reactance between these two Δ's is high (55 per cent based upon rated transformer kva) the short circuit stresses on generator windings and buses, generator breaker duty, etc., are reduced materially. The high voltage windings are provided with full capacity taps 5 per cent above and below the rated voltage of 218 kv. Core and coils were shipped assembled (except for some of the coil end insulation) in nitrogen in a special shipping tank. The transformer tanks, which are 13 ft $2^3/_4$ in. in diameter, were shipped in 3 sections. The complete transformers have a height of 25 ft 3 in. from rail to top of tank and an overall height of 36 ft 2 in. The total net weight per transformer is 415,000 lb, of which 152,000 lb is oil.

Transformers used for delivery of 60-cycle power at 120 kv are water-cooled 3-phase units rated 46,500 kva, 50 deg C rise, 13.2/120 kv; these rated voltages are based upon full rated kva at 85-per cent power factor. The low voltage windings are Δ-connected, and the high voltage windings star-connected; the high voltage windings are provided with 5-per cent full-capacity taps above and below 120 kv. Assembled core and coils were shipped in oil in the lower section of the 2-section tank. Transformer tanks are oval 9 ft 3 in. by 17 ft; the transformers have a height of 21 ft from rail to top of tank and an overall height of 27 ft 3 in. The total net weight per transformer is 282,000 lb, of which 109,000 lb is oil.

Transformers used for delivery of 60-cycle power at 44 kv are water-cooled 3-phase units rated 23,250 kva, 50 deg C rise, 13.2/44 kv. The low voltage windings are Δ-connected, and the high voltage windings star-connected; 46- and 48-kv full capacity taps are provided. The voltage ratings are based upon full rated kva at 85-per cent power factor. The general design of these transformers is similar to the design of the 46,500-kva 120-kv transformers but because of their relatively small size it was possible to ship them in their own tanks in oil.

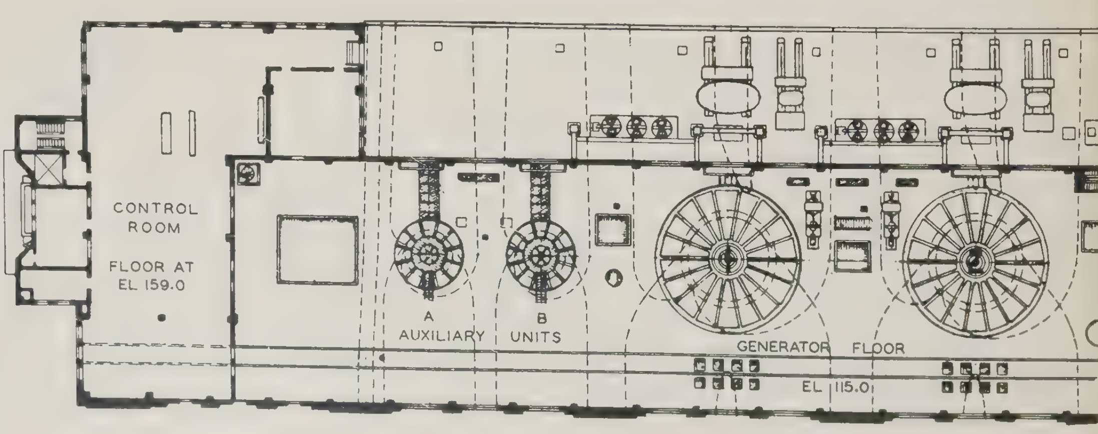
An induced voltage test of 480 kv was specified for the 220-kv transformers, 252 kv for the 120-kv transformers, and 97 kv for the 44-kv transformers. The impulse strength of the 220- and 120-kv transformers is guaranteed to be in excess of line insulation, which consists of, respectively, 14 and 7 10-in. insulator units, spaced $5^3/_4$ in.

Circuit Breakers

All circuit breakers are designed for an interrupting capacity in excess of estimated maximum requirements. The specified interrupting capacity (*OCO* plus *OCO* basis) is 2,500,000 kva for the 230-kv breakers; 1,500,000 kva for the 138-kv breakers controlling the 120-kv circuits; 1,000,000 kva for the 46-kv breakers; 800,000 kva for the 15-kv generator circuit breakers for generating units Nos. 9 and 10; and 600,000 kva for all other 15-kv station breakers.

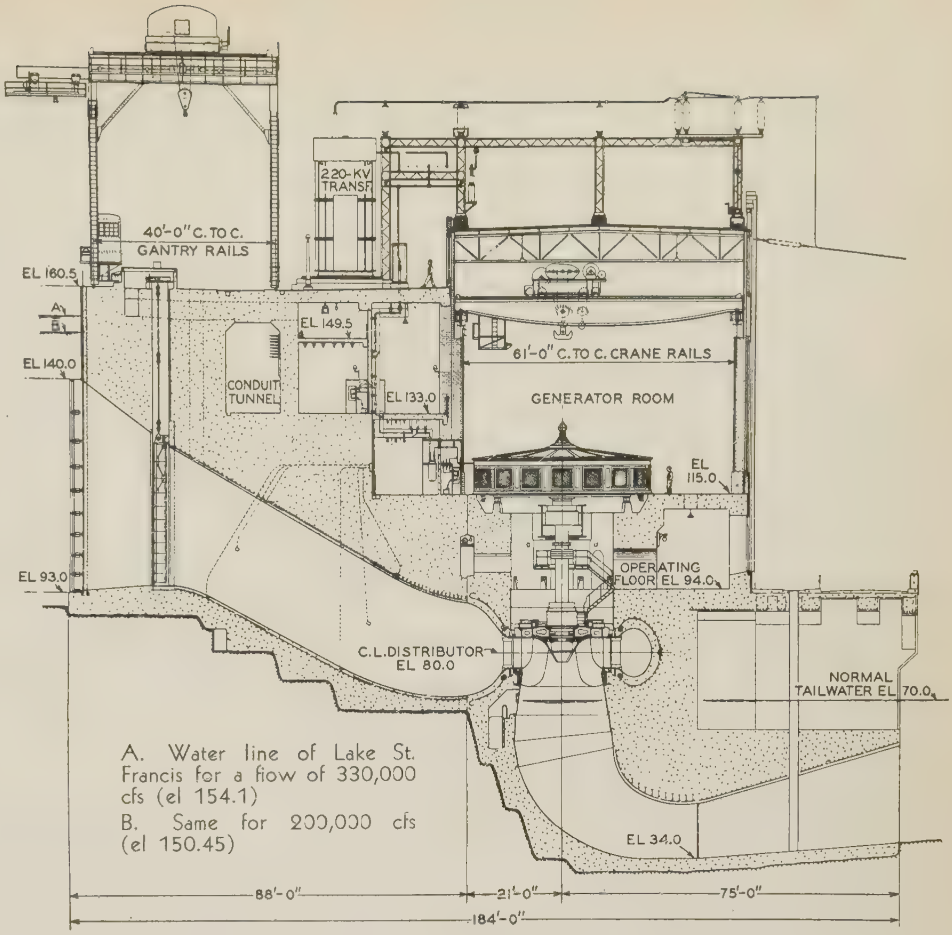
The 230- and 138-kv breakers are of the oil blast explosion chamber contact type and are designed for high speed operation, the time from energizing of trip coil to arc extinction being 0.133 sec (8 cycles on a 60-cycle basis). The one-minute voltage test specified on the assembled breakers was 520 and 312 kv, respectively, for the 230- and 138-kv breakers. Impulse strengths of the 230- and 138-kv breakers are guaranteed in excess of the strength of corresponding line insulation, which consists of, respectively, 14 and 7 10-in. insulator units spaced $5^3/_4$ in.

The 15-kv station breakers meet all A.I.E.E. insulation requirements for 25-kv rating, the one-minute test voltage being 58 kv and the bushing flashover 75 kv. Breakers are designed for high opening and closing speeds, the elapsed time from



Sectional plan of power house from east end to and including main generating unit 2

energizing of closing coil to touching of contacts being 0.35 sec, and the elapsed time from energizing of trip coil to parting of contacts being 0.08 sec. The average breaker speed after parting of contact is approximately 7 ft per second for the 2,400-amp breakers and 11 ft per second for the 600-amp breakers.



Typical transverse section through power house, showing details of a main unit

Bus Systems

Since the transformers are located on the bulk-head, as mentioned previously, the required low voltage bus length is reduced to a minimum. Except for short sections where bar copper proved the most economic, all 15-kv buses are of tubular section, 3-in. *IPS* (iron pipe size) and $1^1/_2$-in. *IPS* copper tubing being used for the power and auxiliary buses, respectively. Bus supports have a flashover of 80 kv and a cantilever strength at the bus line in excess of 4,300 lb. With the system layout used mechanical stresses resulting from short circuits are relatively low, the calculated maximum support stress (stress factor times electromagnetic force) being 510 lb. The support bases are provided with a drip-proof feature so that when installed inverted, water leakage through the supporting slab will not cause flashover. Bushings of rather unusual design were required to take the buses through the bulk head slab which is more than 3 ft in thickness.

High voltage breakers for the 120-kv transformers are located on the bulkhead adjacent to the corresponding transformers, the necessary disconnecting switches and bus connections being mounted on steelwork supported by the power house structure. At the downstream line of the power house connection is made to the circuits of the Montreal Light, Heat and Power consolidated.

From the terminals of the 220-kv transformers connection is made to disconnecting switches supported by steelwork on the power house, and thence through strain buses to a switching station on the downstream side of the power house; there connection is made to outgoing circuits feeding into the Hydro-Electric Power Commission system.

The circuit from the 44-kv transformer passes through disconnecting switches supported by steelwork on the power house structure, thence through a strain bus to a switching station adjacent to the entrance end of the power house. At that point a step-down station is located for local construction equipment and switching is provided for the outgoing 44-kv circuits.

For the sake of interchangeability, the same type of post unit was used for all high voltage buses and disconnecting switches, using 6 units per post for 220-kv, 3 units for 120-kv, and one unit for 44-kv equipment.

Spillway gaps for limiting lightning surge voltages are installed on the bus connections to the high voltage terminals of the 220- and 120-kv transformers. Some columns of the steelwork on the power house roof are extended to a height sufficient to protect the transformers and buses from direct lightning strokes. Reduced insulation is installed on a section of the 220-kv line together with a spillway gap on the transmission tower nearest the switching station.

Control System

Adjacent to each generator on the mezzanine floor (el 133.0) is installed a vertical steel switchboard including the necessary control and indicating equipment for emergency operation of the generator; voltage regulator and rheostats for generator voltage control; protective relays for the generator, step-up transformer, and auxiliary bus section; generator and transformer temperature indicating equipment; the necessary recording instruments for the generator; and the supervisory relays to the master control boards. Adjacent to each generator on the main floor (el 115.0) and mounted on the base supporting the exciter set is a steel pillar containing

the generator field circuit breaker and accessories.

Master control equipment is located in the operating room (el 159.0) at the entrance end of the station. This consists of a benchboard containing the necessary equipment for complete control, regulation, and indication of generator output, and a corresponding vertical control board controlling the auxiliary ring bus and all high voltage switching. The master control boards are designed so that they may be expanded as required to take care of additional generating equipment up to the maximum possible installation of 2,000,000 hp. Both generator control and indicating equipment are installed on the sloping benchboard sections (requiring a total width of 8 in. per generator) thus allowing the operators an unobstructed view of the vertical control boards back of the benchboards.

Individual generator switchboards are on a 250-volt d-c control system; by turning a switch they can be cut off from the 48-volt control system and operated independently. All cable connections, control motor-generator sets, and batteries are on a floor directly below the operating floor. This floor connects with the conduit tunnel running the length of the station. All control cable is carried in corrugated metal trays through the tunnel and thence through conduit embedded in the various floors to the required locations.

Protective Relaying

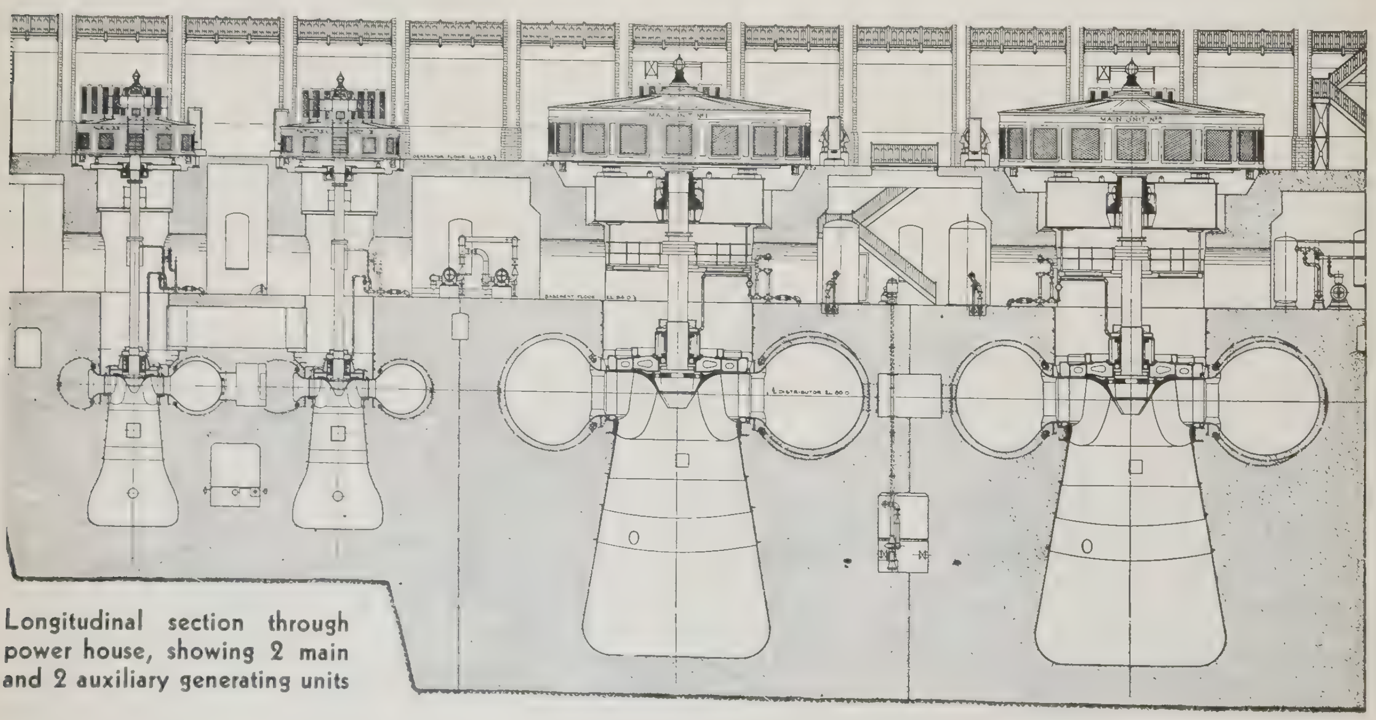
An extensive scheme of protective relaying designed to clear defective equipment in minimum time with the least possible interference with the operation of other equipment is provided. Each major element of station equipment is differentially protected and is provided with adequate back-up protection. To minimize the damage from a generator winding failure, operation of the generator differential relays not only clears the generator and opens the generator field, but also operates a shutdown device for quick closure of the turbine gates. Directional reactance relays together with residual ground relays are used for the 220-kv line protection.

Station Heating and Ventilating

The generators take cool air (125,000 cu ft per minute for each main unit) through pier openings below the generator floor and discharge the heated air through louvers in the generator frame into the power house from which the heated air escapes through the upper windows on both the upstream and downstream side of the station. To keep the headgates free of ice during the winter months, ducts are provided for diversion of heated air into the housings over the headgate openings. Openings with removable covers are installed in the generator floor to permit any desired amount of recirculation of the air passing through the generators, thus allowing the power house to be kept as warm as desired during the winter months. Electric heating is provided for the service building.

Comments

The main feature of the development is its simplicity resulting from a combination of favorable topographic factors and uniformity of stream flow. It is stragetically located convenient to a great industrial area. Additional installation of station equipment and the corresponding additional water diversion can be made at relatively low cost when and as needed to meet industrial demands. At present about $^1/_2$ of the mean river flow is unallocated, but prior to complete diversion there must be cooperation with or acquisition of the rights of the 3 low head hydroelectric plants now operating in this section of the river.



Longitudinal section through power house, showing 2 main and 2 auxiliary generating units

General Power Applications in 1932

Several recent developments in the application of electricity in industry are mentioned in the report of the Institute's committee on general power applications presented herewith.

ALTHOUGH industrial activity as a whole was at a low ebb during 1932, a considerable amount of development and rehabilitation work was carried on by certain industries. Industries are broadly classified as those producing capital goods and those producing consumption goods. During a depression there is little demand for new construction and capital goods but the demand for consumption goods remains fairly constant. There will probably be little demand in the near future for the expansion of plant capacity but it is evident that many existing plants must be remodeled and brought up to date if they expect to meet competitive conditions. Of the companies manufacturing consumption goods many have already appreciated that with the narrowing margin of profit their position and success depends very largely on the continuous reduction of their manufacturing costs and improvement in their product. The trend of the times is consequently toward increased economy of production and improved process control resulting in a better product at a lower cost and it is along these lines that the industrial engineers are working at the present time. It was consequently the opinion of the Institute's committee on general power applications that papers requested or sponsored by it should as far as possible present material which would be helpful and of value along the above lines.

The committee sponsored a session at the 1932 winter convention of the Institute at which 3 engineering papers were presented together with an introductory address by Crosby Field (A'14, F'22) entitled "Economic Conditions and the Engineer." The latter was published in full in the March 1933 issue of ELECTRICAL ENGINEERING, p. 149–51, and presents some very interesting and instructive comments on our present economic situation. The technical papers presented at the convention were as follows:

VARIABLE VOLTAGE OIL WELL DRILLING EQUIPMENT, by A. H. Albrecht

RECENT DEVELOPMENTS IN ELECTRONIC DEVICES FOR INDUSTRIAL CONTROL, by F. H. Gulliksen

CIRCUIT BREAKER PROTECTION FOR INDUSTRIAL CIRCUITS, by H. J. Lingal and O. S. Jennings

Instead of attempting to abstract information regarding the numerous developments in industrial apparatus or regarding industrial applications the committee feels that members interested in such equipment can readily obtain such information directly and more completely from the various periodicals, but the committee does desire at this time to indicate the trend or nature of some of these more important developments.

Gear Motors

During the last year there have been placed on the market a large variety of makes and designs of gear motors and these are being extensively used in industries on account of the saving in space effected, their higher efficiency, and reduced maintenance as compared with open gear or belt drives.

Electronic Control

Although the possibilities of electronic control in various industrial applications have been appreciated for some time there was a marked increase during the last year in the available equipment such as various assemblies of photoelectric relays and special devices. The paper presented at the winter session indicates some of the advantages and possibilities for such equipment in industrial service. Besides the speed and accuracy of electronic equipment together with the freedom from mechanical friction and maintenance, numerous applications have been found where existing types of equipment could not be used and solutions are possible only by means of this newer class of apparatus.

Air Conditioning

A large amount of engineering attention is being devoted to the possibilities of air conditioning, especially in connection with households, offices, and transportation equipment, and in some cases such air conditioning equipment is being combined with heating equipment and more especially with the oil burning automatic type.

Motor Protection

Although fan cooled and explosion resisting motors have been previously mentioned, the advantages of such equipment are being more widely appreciated and many such motors are being installed in the open without protection from the weather whereas previously special housing and protective equipment was necessary. One of the most recent developments in connection with motor protective devices is a thermostat which is mounted on the motor so that when the temperature reaches an excessive value either a signal is given or the motor is shut down depending on how the thermostat is connected. This motor thermostat supplements the standard thermal relay protection and the

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Full text of the annual report for 1932 of the A.I.E.E. committee on general power applications, to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933.

Committee on general power applications: C. W. Drake, *chairman;* A. H. Albrecht, E. A. Armstrong, James Clark, Jr., J. F. Gaskill, John Grotzinger, T. Hibbard, Fraser Jeffrey, A. E. Knowlton, A. M. MacCutcheon, H. A. Maxfield, John Morse, N. L. Mortensen, D. M. Petty, H. W. Rogers, L. D. Rowell, L. M. Shadgett, W. K. Vanderpoel, and M. R. Woodward.

combination of the 2 devices protects against all forms of motor overload.

In conclusion it is desired to emphasize the fact that few of the developments in industry are large or spectacular but it is the steady introduction and application of these new ideas and developments which keep an industry up to date. The fact that many plants have not pursued this policy accounts for the large amount of obsolete equipment in industry at the present time and the large expenditures which it has been estimated are required for rehabilitation in order to modernize the various industrial plants so that they can manufacture on an economical basis.

Precise Timing of Sporting Events

Lack of precise time measuring apparatus for athletic and other sporting events has led to the development of an electric timing system which is accurate to within 0.005 sec for short races and within 0.01 sec for a mile race. This system utilizes a synchronous electric clock and a high speed motion picture camera to photograph simultaneously the runner and the clock dials at the finish of the race. It was put to a practical test in the 1932 Olympics held in Los Angeles, Calif.

By
C. H. FETTER
ASSOCIATE A.I.E.E.
Electrical Research Products, Inc., New York, N. Y.

H. M. STOLLER
MEMBER A.I.E.E.
Bell Telephone Laboratories, Inc., New York, N. Y.

PRECISE TIMING of athletic contests, aeroplane racing, and other similar sporting events in the establishing of new records against time, has been a subject of increasing interest during the last few years. A good runner will travel approximately a yard in $^1/_{10}$ of a second, and races frequently are won by a margin of inches. It is thus evident that if time records are to be employed as a common denominator for comparing athletes and for the just awarding of records, a timing system accurate to the order of $^1/_{100}$ sec is required.

Until recently, athletic races have been timed by stop watches; experience has shown that even with competent timers, the variation of individual readings from the average indicates that the overall probable error is undesirably large. These errors are the result of both mechanical limitations in stop watch design and errors in human judgment, which are involved in starting and stopping the watches at the proper instant. The rate of a good stop watch may be accurate to within a few seconds per day; but in the authors' observation of stop watches and measurements upon them, these rates have shown a wide variation and unless a watch is very closely adjusted and kept in good condition, it is apt to have a considerable error.

Lack of precise time measuring apparatus for athletic events long has been recognized. The requirements which formed the basis for the system to be described were outlined first by Gustavus T. Kirby, chairman of the advisory committee of the Intercollegiate Association of Amateur Athletes of America (I.C.A.A.A.A.) to whom the authors are greatly indebted for cooperation in the development and trial of the timing system.

In a track event the race is started by means of a pistol. The race begins at the visible flash of the pistol, regardless of when the sound reaches the ears of the runners or the ears of a manua timer. This may be contrary to the popular impression

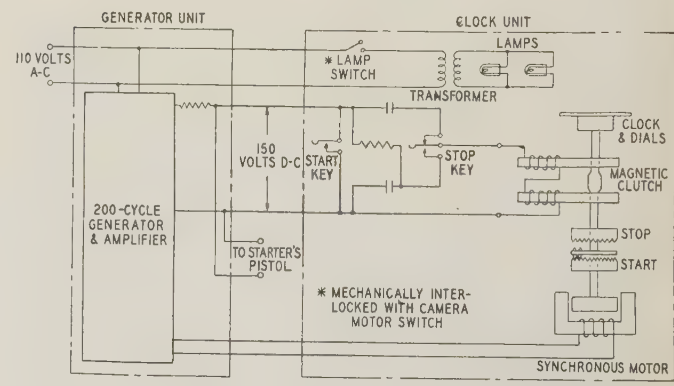


Fig. 1. Schematic diagram of electric timing system

that the sound of the gun denotes the beginning of the race. The dependence upon sound would introduce an error of 0.27 sec in a race where the distance between starter and timers was 100 yd. The race is finished when the torso of the runner has reached a line on the ground which defines the end of the course. A tape stretched between 2 posts is there merely for the guidance of the runners and the judges, and has nothing to do with the finish line of the race. The standard tape consists of a loosely woven yarn and frequently it is out of line with the finish mark on the ground, because of wind pressure. The tape may be broken by a runner's hand before he crosses the line, or a runner by falling at the finish

Full text of a paper (No. 33-86) to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26-30, 1933.

line may even finish a race without breaking the tape; because of these facts, any mechanical contrivance associated with the tape was out of the question. In addition, as far as athletic events are concerned, timing was not the sole problem; judging the position of the second, third, and sometimes the fourth runner, particularly in elimination contests, was found to be of considerable importance. Therefore, it was concluded that the only satisfactory method of timing and judging a race was by means of a motion picture camera that would photograph both the action of the contestant at the finish, and his time. Mr. Kirby, without the authors' knowledge at the time, also had arrived at the same conclusion, and a discussion and interchange of views in the summer of 1931 marked the beginning of this development. As a result of his aggressive interest and kind cooperation, the camera used has been called the Kirby Two-Eyed Camera.

Fig. 3. Amplifier used with the tuning fork generator, and camera clock

Apparatus and Method of Operation

The timing system was developed primarily to meet track conditions and to enable the measurement of time with an error not to exceed one $^1/_{100}$ sec in a one-mile or shorter race. Briefly described, the system comprises a 200-cycle frequency generator, the time standard of the system; a synchronous motor; a clock driven by the synchronous motor through an electromagnetic clutch; and a high speed motion picture camera equipped with 2 lenses, one to photograph the action of the runner at the finish line and the other to photograph the clock. The clock consists of 3 concentric dials of which the inner dial, with 100 divisions, rotates at one revolution per second; the middle dial, having 60 divisions, rotates once a minute; and the outer dial, with 60 divisions, revolves at one revolution per hour. In this way it is necessary to photograph only a small segment of the 3 concentric dials in order to obtain the time in minutes, seconds, and hundredths seconds.

Operation of the system is evident from the schematic diagram, Fig. 1. The synchronous motor

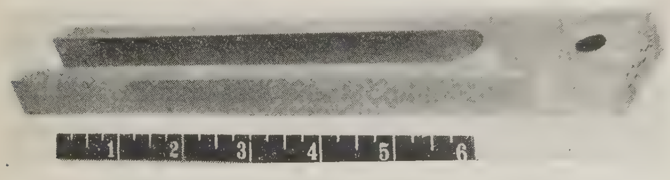


Fig. 2. The tuning fork is the time standard of the system

rotates continuously. The clock dials are engaged with the rotating motor by means of a polarized magnetic clutch operated by the discharge of a condenser at the beginning of the race through a contact in the starter's pistol; this starts the clock from its zero position. Just prior to the end of the race the camera is operated to photograph the runner and the time registered by the clock. After the race is over, the clock mechanism is disengaged from the motor and the dials are reset to zero; the system then is ready for the next event.

Frequency Generator

The 200-cycle frequency generator contains a tuning fork and an amplifying system. The tuning fork is the heart of the timing system for measurements of time are dependent upon its rate of vibration. The utmost care, therefore, has been taken in the design, construction, and operation of the tuning fork and its associated parts in order to maintain the fork frequency as closely as is practicable to 200 cycles per second. The fork itself (see Fig. 2) is made of a special alloy which reduces the effects of temperature change on frequency to a minimum. In addition, the fork is mounted in a heat insulated box provided with a thermostatically controlled heater capable of keeping the fork temperature essentially constant though the generator may be operating for an indefinite period of time in the tropics at 120 deg F or in northern winter weather of 20 deg F below zero.

Tests made under extreme temperature conditions have shown that the resulting frequency change contributes but a minor part of the total system error. The fork and the electromagnetic driving and pick-up coils are held together by a strongly built casting which, in turn, is suspended by rubber supports to eliminate the effects of external mechanical vibrations that might be of a frequency such as to change the period of vibration of the fork. As a further precaution, the whole fork box also is suspended by similar rubber supports.

Associated with the tuning fork is a 3-stage vacuum tube amplifier used to maintain oscillations in the fork and also to provide the power output necessary to drive the synchronous motors. The output of the first 2 stages of the amplifier is coupled electromagnetically through the fork to the amplifier input so that the loss through the fork is offset by the gain in the amplifier. The fork oscillations are maintained by amplifying the small currents generated in the pick-up coils by the movement of the fork prongs, and using this amplified energy to drive the fork by means of the driving coils. A limiting

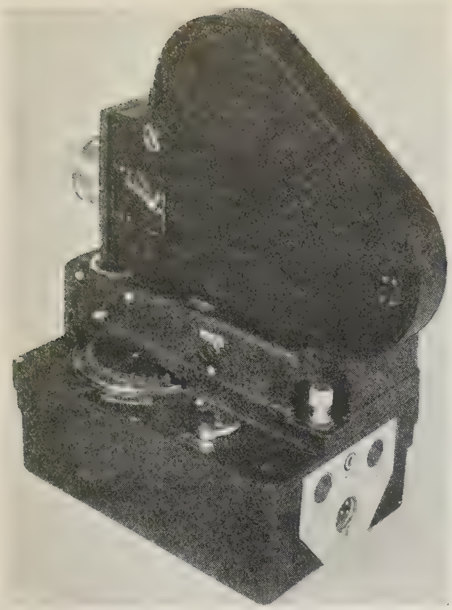


Fig. 4. Camera and clock assembly

Fig. 5. Synchronous clock motor; note starting lever at bottom and clutch magnet at left

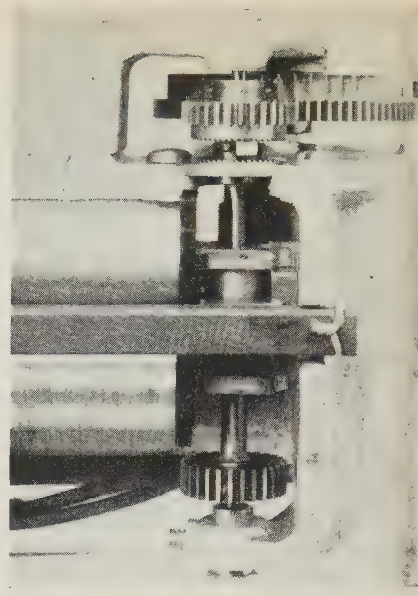


Fig. 6. Polarized magnetic clutch for starting and stopping clock dials; note clutch teeth

device is placed in the circuit which automatically limits the amplitude of the fork with changes in line voltage of the amplifier power supply and also reasonable aging of the vacuum tubes. Such a device is necessary in order that the amplifier will not overload or the amplitude of the fork vibrations vary sufficiently to cause a change in frequency. The entire apparatus may be operated from commercial power sources with voltages from 100 to 125 volts and frequencies from 50 to 65 cycles. A photograph of the generator and clock is reproduced in Fig. 3.

As a further precaution to insure proper operation, a simple checking circuit is provided which permits an overall check of the oscillating circuit and insures that the vacuum tubes are functioning satisfactorily. Although this checking circuit will not directly check the frequency of the fork, it so checks the associated circuits as to practically guarantee that the fork frequency is correct.

The third stage of the amplifier is a push-pull power amplifier which is operated by energy diverted from the tuning fork driving coils. This stage of amplification provides ample energy to drive 2 synchronous clocks simultaneously and is arranged so that the frequency is independent of the amplifier load. The entire equipment is operated from an a-c source, a small portion of the rectified and filtered plate power supply being used to operate the clutch mechanism. Though the amplifier and clutch thus are interconnected, they are isolated sufficiently well electrically so that the clutch operation has no effect upon the amplifier that might cause a change in frequency.

The Clock and Its Mechanism

The clock assembly includes a synchronous motor which is connected by means of a clutch to the dials, through a gear train.

Mechanical design of the clutch and clock mechanism involved the reduction of the moment of inertia of all high speed rotating parts to a minimum, and the use of specially hardened parts for the clutch members to minimize tooth wear. In order to provide the clutch with a sufficiently high operating speed, the clutch magnets were made relatively small in size and they are operated by the discharge from a condenser. This permits the use of much greater power for a few thousandths of a second than heating limits would allow if power were applied continuously.

The dials appear on the top of the clock assembly; they can be reset by means of a peripheral ring surrounding the outside dial. A lamp house, mounted on top of the clock mechanism, provides a support for the camera and contains 2 ordinary 6-volt lamps for clock dial illumination. The auxiliary optical system in the camera is designed to photograph the clock dials while the main camera lens simultaneously records the action. A complete description of the camera is given in a paper by F. E. Tuttle of the Eastman Kodak Company, Rochester, N. Y., presented at the April 1933 convention of the Society of Motion Picture Engineers, held in New York, N. Y. A photograph of the camera clock assembly is reproduced in Fig. 4.

"Stop" and "start" buttons are provided on the camera clock so that it may be operated independently for testing. A jack also is provided in parallel with the "stop" key so that if the clock be used without the camera, a cord terminated in a stop switch may be inserted in this jack to permit manual stopping of the clock by a human timer; this gives instantly the time, except for the error introduced by the reaction time of the operator.

Starter's Pistol

The starter's pistol is provided with a contact inside of the butt which is adjusted to operate at the

instant the hammer strikes the cartridge. Other methods have been proposed for providing this function, but the contact method seems to be the most reliable, and in hundreds of tests never has failed.

Analysis of Errors in Timing System

In designing a system of this type for a precision of $^1/_{100}$ sec, it has been necessary to consider carefully what errors may be involved. It will be helpful to list the possible errors and then analyze them individually. These errors are as follows:

1. Variation in standard frequency supply.
2. Error in operating the contact on the pistol.
3. Variation in phase angle of lag of synchronous clock motor.
4. Variation in operating time of clutch magnet.
5. Error due to limited number of teeth on clutch.
6. Error due to initial dial setting.
7. Observational error in reading dials.

In actual tests covering a period of several days, the frequency of a sample stock tuning fork and its associated driving circuit did not vary more than ± 9 parts in a million, when calibrated against a quartz crystal oscillator having an error less than 1 part in a million. Other sources of possible error such as variations in the vacuum tubes used to drive the fork and in power supply voltage, make the maximum total indicated error ± 25 parts in a million, or ± 1 part in 40,000, or at a rate of about 2 sec in 24 hr. This is somewhat better than the precision

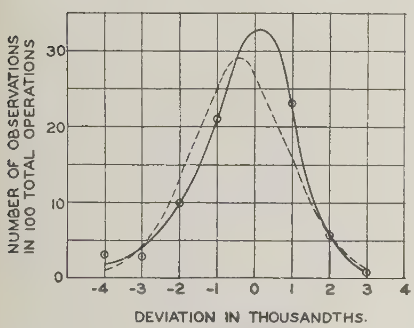


Fig. 7. Frequency distribution of error in operation of clock

generally attained in the highest grade watches. In practice, it means that in a one-mile race the error due to the fork alone will not exceed, and probably will be less than, 0.0075 sec, while in the shorter races, it will be entirely negligible, being only about 0.002 sec in the quarter-mile.

The ignition time of a cartridge has been studied exhaustively by ammunition manufacturers, and is of the order of 0.001 sec or less, depending upon the kind of powder used. Since the "start" circuit contacts do not close until the moment the cartridge is hit, the acceleration time of the trigger is not a factor.

The synchronous motor is of the variable reluctance type shown in Fig. 5. The rotor has 20 teeth and operates at 600 rpm on 200 cycles. The normal phase angle of lag is approximately 15 electrical degrees, but this angle may vary from 5 to 25 deg between minimum load with maximum input, and maximum load with minimum input. However, the error under any given conditions at a particular race will not exceed 10 electrical degrees or only 0.00014 sec.

The clutch magnet, shown in Fig. 6, has a polarized magnetic circuit and therefore tends to hold firmly in either position after operation. The starting winding is closed by the contact on the starter's pistol. The time required to operate the magnet is 0.006 sec, but the variation in this is small since both the mechanical and electrical inertia of the circuit are substantially constant. Therefore, allowance is made in the camera clock for the mean value of this error by setting the $^1/_{100}$-sec dial ahead 0.006 sec. In the case of the manually stopped auxiliary clock no such adjustment is made since the time of stopping is substantially equal to the time of starting and they thus cancel out. An allowance of 0.001 sec may be made for lack of complete compensation for this error.

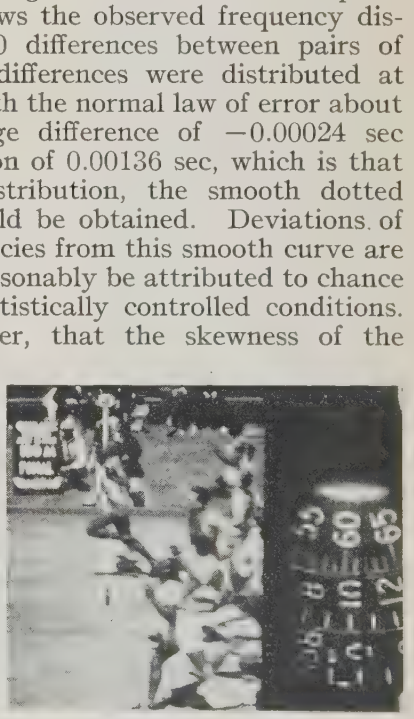
Another source of error is introduced by the clutch teeth. Since there are 80 possible locking positions of the clutch, the maximum error is $^1/_{80}$ of one revolution of the motor or 0.0013 sec from this cause. High speed motion pictures of the clutch operation showed no bouncing or slippage of the clutch members, and the operation was found to be always correct to the nearest tooth.

Error due to the initial dial setting is not more than 0.001 sec if the clock dials have been adjusted properly and the operator uses ordinary care at the time of resetting. The dials are located in the correct initial position by means of a detent in the reset ring.

Error due to inaccurate reading of the dials is, of course, a human error and is largely a matter of skill in estimating fractions of the $^1/_{100}$-sec divisions on the inner dial. This should be practicable within 0.2 division or 0.002 sec.

A laboratory check on the foregoing analysis was made using 2 clocks which were simultaneously started and stopped 100 times by means of common push buttons, resetting between successive operations. Figure 7 shows the observed frequency distribution of the 100 differences between pairs of readings. If these differences were distributed at random in accord with the normal law of error about the observed average difference of −0.00024 sec with an rms deviation of 0.00136 sec, which is that of the observed distribution, the smooth dotted curve of Fig. 7 would be obtained. Deviations of the observed frequencies from this smooth curve are greater than may reasonably be attributed to chance variations under statistically controlled conditions. It is found, however, that the skewness of the

Fig. 8. Finish of 100-m final, 1932 Olympic tryouts, Palo Alto, Calif.



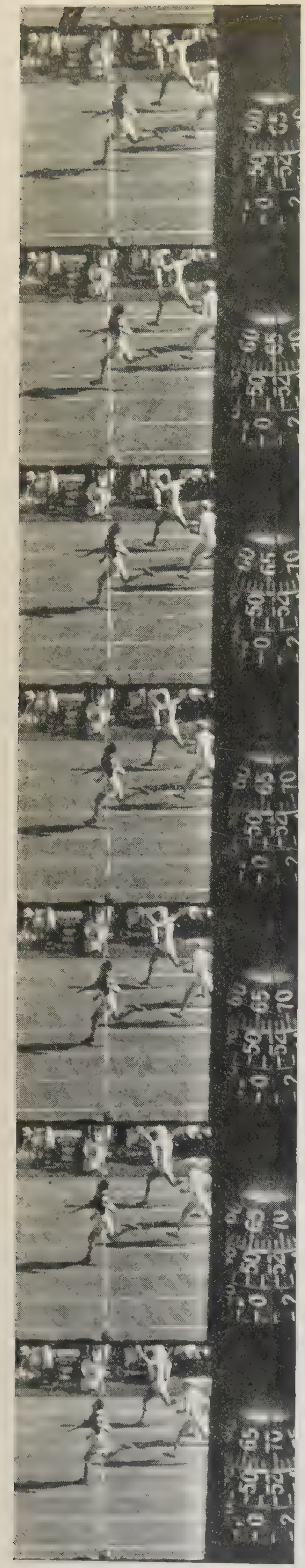


Fig. 9. Finish of 400-m hurdle final, Xth Olympiad, Los Angeles, Calif., 1932. The middle frame was chosen as the finish of the race

distribution is significantly different from zero and that the observed distribution can be fitted reasonably well by the first 2 terms of the Gram-Charlier series; this may be taken as evidence of statistically controlled conditions where the objective distribution of error for a given system is non-symmetrical. (See "Economic Control of Quality of Manufactured Product," by W. A. Shewhart.)

Of course, the data in Fig. 7 represent the comparison of one system against another instead of one system against an absolute standard. Assuming that for all practical purposes the objective distribution of error for one system is functionally the same as that for the other, and that the errors of one system are not correlated with those of the other, then it follows that perhaps the best estimate of the probable error of an observation for a single system is 0.00065 sec and the skewness of the single system is approximately twice that observed using the measure customarily adopted in the theory of quality control.

The fact that the data gave this kind of evidence of statistical control supports the contention that erratic assignable causes of variability have been eliminated successfully. Furthermore, the fact that the distribution can be represented approximately by the first 2 terms of the Gram-Charlier series, together with the positive evidence of statistical control, leads to the conclusion that a single error of a single system due to starting and stopping should not be expected to be greater than 0.006 sec more than once in 100 times, and that it will not exceed 0.0014 sec more than 50 per cent of the time.

It is thus a fair statement to make that the overall accuracy of the system is within 0.005 sec for short races and within 0.01 sec for the mile run. This degree of accuracy should satisfy the public's demand for drawing nice distinctions in comparing the achievements of their favorite athletes, and affords a sound basis for the establishment of track records. Any higher degree of accuracy would be superfluous and inconsistent with human limitations.

Use of the Equipment

On May 14, 1932, the timing system in model form had its first unofficial use at the Columbia-Syracuse track meet at Baker Field, New York, N. Y. It was used subsequently at the Princeton-Cornell meet May 21, 1932, and at the I.C.A.A.A.A. annual meet at Berkeley, Calif., in July 1932. At Palo Alto in July it was used unofficially in the Olympic tryouts. An example of the value of the device from a judging standpoint can be seen in Fig. 8, which shows 5 contestants bunched very close together at the finish line. Subsequent frames from the same piece of film showed definitely the order of finish of these contestants, the first 3 of whom were selected for the American Olympic team.

At the Xth Olympiad held in Los Angeles, July 31–August 8, 1932, the timing system was used semi-officially for every running event. It was used officially for judging but unofficially for timing inasmuch as timing to the hundredth second had not yet been recognized. Figure 9 shows the finish of the 400-m hurdle in the Olympic games; 7 frames

Fig. 10. Tolan-Metcalfe finish in the 100-m final, Xth Olympiad, Los Angeles, Calif., 1932. Tolan won by a very small margin

of this picture are shown in order to demonstrate the need for hundredth second timing. From the first to the seventh frame shown, the runner has advanced by only a few inches in a time of about 0.04 sec. The committee chose the middle frame as the finish of the race; the recorded time as shown is 51.67 sec. It is of interest to note after the film was viewed by the committee, that several decisions were changed at the Olympic games; the most important of these occurred in the same race illustrated in Fig. 9, in which Findlay of Great Britain was awarded third place after the medal already had been given to Keller of the United States. Figure 10 shows the effectiveness in the use of the camera clock in judging and timing the famous Tolan-Metcalfe finish in the 100-m final, where Tolan won by a very small margin.

Use of the timing system in such events as aeroplane races was demonstrated in September 1932, at the Cleveland air races. Two cameras, started together and running in synchronism, were used at the beginning and end of a straightaway speed course, in which case the elapsed time is the difference between the 2 readings. Figure 11 shows Major James Doolittle breaking the world's record for land planes over a 3-km course at an average speed of 294.90 mph.

The timing apparatus was used officially at the Amateur Athletic Union indoor meet held on February 25, 1933, in Madison Square Garden, New York, N. Y. Several races were extremely close and in the 60-yd dash the official decision was withheld

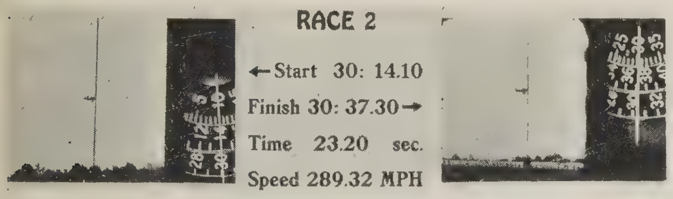


Fig. 11. Major James Doolittle breaking world's speed record for land planes over 3-km course; average speed for 4 consecutive trials, 294.90 mph

until the film was viewed by the committee. At the I.C.A.A.A.A. indoor meet held on March 4, 1933, in the 258th Field Artillery Armory, New York, N. Y., the second, third, fourth, and fifth places in the 70-yd hurdle were changed from the announced decision of the judges, after they viewed the timing film. As a further result, several changes were made in team scores and Harvard replaced Princeton in fifth place.

As a result of the use of this system formal approvals have been received from the International Amateur Athletic Federation, which is the controlling body of amateur athletes for the Olympics; by the A.A.U., which is the governing body of amateur athletics in the United States; and by the I.C.A.A.A.A. Formal approval also has been given by the National Aeronautic Association; and in April 1933 approval was given by the Federation Aeronautique Internationalle, with headquarters in Paris, France, under whose regulations all official international aeroplane speed events are run.

Industrial Applications

It is expected that many industrial problems will lend themselves to solution by means of the apparatus described, although time and space do not permit covering in detail that phase of precise timing. We believe that the apparatus described can be used in many places as a tool where permanent records are desired and where methods heretofore in use have not been sufficiently accurate.

Electrical Machinery Developments in 1932

Recent developments in the 5 major classes of electrical machinery are outlined in the following report of the Institute's committee on electrical machinery. Considerable operating experience with equipment previously developed was secured and also is summarized.

DURING the current year the Institute's committee on electrical machinery has functioned, as previously, through 5 major subcommittees, namely: synchronous machines, induction machines, d-c machines, transformers, and mercury arc rectifiers. These subcommittees have continued their activities in following the preparation of standards, in reviewing progress and development of the art, and in examination of papers offered for presentation at the stated conventions of the Institute.

Noteworthy advance has been made by the committee in recommendations for impulse testing of transformers and in revision of low frequency dielectric tests for transformers. A preliminary report on a test code for synchronous machines has been printed. Active progress is being made in the development of methods and testing devices for determining load losses and input-output efficiency of induction motors, as a preliminary to formulating a test code for induction machines. A test code for d-c machines is in preparation.

Full text of the annual report for 1932 of the A.I.E.E. committee on electrical machinery, to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933.

Committee on electrical machinery: S. L. Henderson, *chairman;* P. L. Alger, B. L. Barns, E. S. Bundy, H. E. Edgerton, J. E. Goodale, T. T. Hambleton, J. L. Hamilton, A. L. Harding, C. F. Harding, E. W. Henderson, L. F. Hickernell, J. Allen Johnson, J. J. Linebaugh, H. C. Louis, W. V. Lyon, A. M. MacCutcheon, O. K. Marti, V. M. Montsinger, S. H. Mortensen, R. W. Owens, R. H. Park, E. B. Paxton, H. V. Putman, K. A. Reed, O. E. Shirley, F. V. Smith, R. G. Warner, and C. A. M. Weber.

Among the technical papers reviewed and accepted by the committee during the year are many important contributions in the fields covered. A brief outline of notable advances and progress during 1932 in the field of electrical machinery follows:

Synchronous Machines

A considerable part of the work on synchronous machines during this past year has been the improvement of details of design and manufacture. Progress has been made in high voltage coil insulation and in the reduction of fixed and stray load losses of high speed machines.

There has been no increase in the size of turbine driven alternators since the 1931 report. The 2 200,000-kva 1,800-rpm machines (GE)[1] in the Brooklyn Edison Company's plant have operated for some time and heat rate tests made on both machines show results better than the guarantees. A 183,333-kva 165,000-kw 1,800-rpm single-element turbine alternator (W) is being built for the Philadelphia Electric Company. This generator has 2 stator windings and is cooled by external propeller type blowers. A 166,666-kva single-shaft turbine alternator (GE) has been delivered to the Chicago District Electric Generating Corporation. It also has 2 stator windings and is the largest machine shipped with the armature completely wound. The inside armature frame with the winding is arranged so it may be assembled within an enclosing casing which also houses the 4 separately driven ventilating fans and the surface air coolers.

Experience is being obtained with high voltage turbine generators. Eight units from 3 different manufacturers had an equivalent of 22 turbine-generator-years of service up to January 1933. A more detailed tabulation is given in Table I.

Table I—High Voltage Turbine Generators

Year Placed in Service	Station	Unit No.	Capacity Kilowatts	Voltage	Manufacturer
1928	Powerton	1	52,500	22,000	GE
1929	State Line	1 (3 generators)	200,000	22,000	GE
1929	Powerton	2	52,500	22,000	GE
1930	Powerton	3	105,000	22,000	GE
1931	Michigan City	1	68,000	22,000	W
1931	Waukegan	5	115,000	18,000	AC

The maximum capacity of waterwheel driven generators has not been increased during the year, although preliminary designs for a generator in excess of the capacity of any generators previously built have been made in considerable detail. Mechanical improvement in the line of simplification of bearing oiling system and other details has been made on the waterwheel generators.

Developments in the field of synchronous motors include the first (GE) totally enclosed fan-cooled type, particularly designed for use in class *I*, group *D* explosive gas locations. The ventilating air enters at the driving end and passes over the inner shield, across the back of the stator punchings, and is discharged at the collector end. The collector rings are enclosed and excitation is provided by a motor-generator set. A number of synchronous motors were applied in municipal water pumping stations. The trend in these machines is toward high efficiencies and in one case, an 800-hp 900-rpm motor (W) had a guaranteed efficiency of 97.6 per cent. It is believed that the first synchronous motors to drive power house draft fans were supplied to the Hawaiian Electric Company. These motors were a 2-speed motor rated 300 hp at 600 rpm, and 700 hp at 900 rpm (W) to drive an induced draft fan and a 200-hp motor at 1,200 rpm (W) for the forced draft fan.

Part winding starting has found increasing use on synchronous motors where starting requirements are extremely heavy, such as on flour mill line-shaft drive and cement mill tube-mill drive. A recent installation of 5 250-hp 277-rpm and 1 600-hp 138-rpm synchronous motors (EM) for flour mill line drive, the first of its kind, utilizes 5 part-winding steps in the motor to secure proper motor accelerating characteristics. The part winding steps are arranged to provide starting torque in increments from 60 per cent normal torque to 175 per cent normal torque. These torque steps are secured either manually or automatically to insure smooth starting without belt slippage.

A 60-kva 1.0-power factor 4,800-cycle 3-phase generator (GE) represents an advance in the use of high frequency for industrial heating. Two 60-kva 1.0-power factor 4,800-cycle single-phase generators (W) are now being built.

The 2 30,000-kw frequency changers (GE) at the Richmond Station of the Philadelphia Electric Company are now supplying single-phase 25-cycle power to the main line electrification of the Pennsylvania Railroad between New York and Philadelphia.

Induction Machines

The use of totally enclosed motors and especially the use of totally enclosed fan-cooled motors has increased considerably. An increasing demand is being experienced for splash or hose-proof motor construction. These machines are built suitable for outdoor installation, use in dairies, or where a hose is used in cleaning up the floors. A movement is underway to revise the definitions of the various types of enclosures.

The use of motor-reduction units has increased materially. This apparatus has been defined as follows: A motor-reduction unit is a motor with an integral mechanical means of obtaining a speed differing from the speed of the motor.

An outstanding development in the fractional horsepower single-phase motors has been first, the development of capacitor-start capacitor-run single-phase motors, employing usually a transformer and a paper condenser, and more recently, the development of capacitor-start induction-run single-phase

[1] Manufacturer designation:
AC—Allis-Chalmers Manufacturing Company
BB—American Brown Boveri Company
EM—Electric Machinery Manufacturing Company
GE—General Electric Company
W—Westinghouse Electric and Manufacturing Company

Table II—Mercury Arc Rectifier Units Placed in Operation During 1932 or on Order December 31, 1932

Purchaser	No. of Sets	D-c Volts	Kilowatts Per Set	Total Kilowatts	Type of Control	Service	Placed in Service	Manufacturer
I. G. Farbenindustrie for Standard Oil Co. of Louisiana	1	3,500 9,600	2,200	2,200	Manual	Electrochemical	1932	BB
Long Island Railway Co.	4	650	3,000	12,000	Automatic	Railway	1932	AC
N. Y. Board of Transportation	9	625	3,000	27,000	Automatic remote control	Subway	On order	W
N. Y. Board of Transportation	13	625	3,000	39,000	Automatic remote control	Subway	*1932	GE
N. Y. Board of Transportation	15	625	3,000	45,000	Automatic remote control	Subway	*1932	GE
N. Y. Board of Transportation	13	625	3,000	3,900	Automatic remote control	Subway	*1932	GE
Philadelphia, City of	2	630	3,150	6,300	Manual	Railway	1932	AC

* Installed ready for service.

Table III—Mercury Arc Rectifier Units: Comparison 1931–1932

	1932		1931	
	No. of Sets	Kilo-watts	No. of Sets	Kilo-watts
Placed in service	48	143,500	57	127,845
Being installed			14	41,200
On order	9	27,000	34	102,300
Grand total for year	57	170,500	105	271,345
Total number units in service, Dec. 31st	*228	448,879	180	305,379

* Includes 41 units installed and ready for service.

motors, employing a low voltage condenser of relatively large capacity for starting purposes only. The low voltage capacitor-start single-phase motor is finding its first application in the household refrigerator field.

The greatly increased activity in the air conditioning field has resulted in motors being developed to operate fans, blowers, and water agitators, which are quiet and have long life of bearings.

Dual motors, alternating and direct current on one shaft, have been developed to meet the requirement of refrigerating trucks and railroad cars and air conditioning passenger cars. The d-c motor is used to drive the refrigerating machine when the truck or car is in motion, the current being supplied from the d-c generator on the truck or car, and the induction motor is used when the truck or car is standing, the motor being connected to the a-c city distribution system.

D-C Machines

The largest 350-rpm d-c motors so far constructed are reported for the current year. Six 3,500-hp 175/350-rpm d-c motors (AC) were placed in service on 6 finishing stands of a 76-in. continuous-strip mill, power being supplied by 3 5,000-kw 3-unit motor-generator sets. Three 3,500-hp 175/350-rpm d-c motors (GE) were placed in service on the finishing stands of a 72-in. continuous hot-strip mill for the Otis Steel Company, power being supplied by 2 4,000-kw 3-unit motor-generator sets.

A light weight d-c generator (W) has been completed. It consists of 3 units, one rated 8-kw 115-volts and 2 rated 2.5-kw 3,000-volts at 2,200 rpm. Two bearings are used, mounted in cast magnesium brackets. Total weight of the machine is 549 lb.

A gas electric "crawler" type track welder (W) has been completed. This machine is designed with low head room to move along the shoulder of the road bed, so as to clear the rolling stock and furnish power for building up worn rail ends by arc welding, and in addition, to furnish power for a grinder and nut tightener. A series motor taking power from the welding generator is used to move the welder along the track.

Transformers

The activity of the transformer subcommittee in developing standards for the commercial impulse testing of power transformers has borne fruit in an agreement upon a tentative test code. This test procedure, including a program of applied impulse tests made with the transformer excited, was presented at the Institute's 1933 winter convention in a paper by Messrs. Vogel and Montsinger. Meanwhile the ranks of the manufacturers prepared to make commercial surge tests have been augmented by the installation by Allis-Chalmers of a high capacity surge generator capable of delivering 2,000,000 volts, with complete cathode ray and pontentiometer equipments and arrangements for synchronizing the impulse with the peak of a normal frequency alternating voltage wave. Commercial surge tests have been applied to transformers with such ratings as 20,000 kva, 132 kv (GE); 2,000 kva, 69 kv (GE); 4,500 kva, 132 kv, 25 cycles (GE); 20,000 kva, 230 kv (W); 20,000 kva, 132 kv, 25 cycles (W); 10,000 kva, 132 kv (W); 4,500 kva, 132 kv, 25 cycles (W); and 20,000 kva, 115 kv, 3-phase autotransformers (W).

Four of the largest 230-kv single-phase transformers yet constructed have been built (GE) with ratings of 45,000 kva self-cooled and 60,000 kva with air blast. With a total weight of 393,000 lb, it was necessary to ship them in nitrogen in special low slung tank cars.

Transformers have been supplied (AC) with a low pressure system for automatically maintaining inert gas protection without chemicals or moving mechanical parts. The system involves an oil seal in an expansion tank which isolates the inert gas from the atmosphere and permits considerable change in oil level in the main tank with slight change of pressure.

In the field of load ratio control, a new type *UT* tap changer (W), smaller and less expensive than its predecessors, applicable to small transformers and capable of operation under short circuit, has been

actively supplied. A quick operating automatic tap changer (AC) has been developed for large distribution and small power transformers up to 15 kv. Two 40,000-kva 3-phase regulating transformers (W), simultaneously controlling regulation of phase angle and voltage, were installed in New York. A self-contained automatic step voltage regulator (GE) is available for 3-phase rural circuits of 50 amp. at 4,800 to 13,800 volts.

Self-contained surge-proof distribution transformers employing de-ion gaps (W) have been extended to the 4,800 and 6,900 volt classes. The line of self-protecting stud-type-bushing distribution transformers (AC) has been supplemented with provisions for mounting surge diverters either internally or externally.

Pyranol (GE) and inertol (W) non-inflammable non-explosive mediums, developed to replace mineral oil where other methods of preventing fires are not practicable, have been developed and applied to low-voltage network transformers.

Mercury Arc Rectifiers

Tables II and III give general data on mercury arc rectifier activities during the year. Nine of the 3,000-kw 625-volt sectional rectifiers (W) mentioned in last year's report were ordered by the New York Board of Transportation.

An innovation in the rectifier field was the equipment of a standard 3,125-kw 625-volt railway rectifier with automatic grid voltage control (AC). A constant d-c voltage is held independent of load and supply voltage variations.

Ten of the New York Board of Transportation 3,000-kw rectifiers (GE) were placed in service, supplying power for the operation of the 8th Avenue Subway, New York.

Present Practice in

Installation and Performance of High Voltage Lightning Arresters

A Joint Subcommittee Report*

In an effort to determine present operating practice relative to the installation and performance of high voltage lightning arresters on electric power systems, the A.I.E.E. subcommittee on lightning arresters and the N.E.L.A. subject committee on lightning arresters circulated a joint questionnaire on that subject to 22 companies in various parts of the United States. Data obtained in the replies to the questionnaire are summarized in this report. While it is believed somewhat premature to draw definite conclusions, nevertheless certain definite trends may be observed.

REALIZING the importance of present operating practice relative to lightning arrester installation and performance as affecting suitable standards for the design of lightning arresters and methods of protection, the subcommittee on lightning arresters of the A.I.E.E. committee on protective devices and the subject committee on lightning arresters of the N.E.L.A. protective equipment subcommittee, have cooperated in a joint questionnaire on lightning arresters for 11 kv and higher voltages. From the membership of these 2 committees,* the questionnaire has been circulated to 22 companies located throughout the United States; 17 replies† have been received from typical operating companies, representing approximately 34 per cent of the electric power industry, based upon output in 1931, or approximately 26 per cent based upon miles of

Full text of a report (A.I.E.E. Paper No. 33-81) to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933. This report was prepared prior to the organization of the Edison Electric Institute.

* Members of A.I.E.E. committee on protective devices—Hollis K. Sels, *chairman*, Pub. Serv. Elec. and Gas Co., Newark, N. J.; H. E. Allen, Pa. Water & Pwr. Co., Baltimore, Md.; I. W. Gross, Am. Gas & Elec. Co., New York, N. Y.; Herman Halperin, Commonwealth Edison Co., Chicago, Ill.; W D. Hardaway, Pub. Serv. Co. of Colo., Denver, Colo.; C. F. Harding, Purdue Univ., Lafayette, Ind.; W. D. Ketchum, The Commonwealth and Southern Corp., Birmingham, Ala.; H. A. P. Langstaff, West Penn Pwr. Co., Pittsburgh, Pa.; K. B. McEachron, Genl. Elec. Co., Pittsfield, Mass.; J. R. McFarlin, Elec. Serv. Supply Co., Philadelphia, Pa.; H. L. Melvin, Elec. Bond and Share Co., New York, N. Y.; O. M. Opsahl, Westinghouse Elec. and Mfg. Co., E. Pittsburgh, Pa.; A. H. Schirmer, Am. Tel. and Tel. Co., New York, N. Y.; and H. H. Spencer,† New Eng. Pwr. Engg. & Serv. Corp., Boston, Mass.

* Members of N.E.L.A. subject committee on lightning arresters (1932–33)—N. L. Pollard (deceased March 3, 1933), *chairman*, formerly of United Engrs. and Constructors, Newark, N. J.; J. Bankus, Portland Genl. Elec. Co., Portland, Ore.; H. W. Collins, The Detroit Edison Co., Detroit, Mich.; J. H. Ferry,† Potomac Elec. Pwr. Co., Washington, D. C.; L. R. Gamble, The Washington Water Pwr. Co., Spokane, Wash.; H. A. Randall, Duquesne Light Co., Pittsburgh, Pa.; J. E. Sheehan, Houston Ltg. & Pwr. Co., Houston, Texas; H. S. Sladen, Kansas Gas & Elec. Co., Wichita, Kan.; W. C. Sontum,† Pa. Elec. Co., Johnstown, Pa.; H. H. Spencer,† New England Pwr. & Serv. Corp., Boston, Mass.; and E. C. Williamson, The Tenn. Elec. Pwr. Co., Chattanooga, Tenn.

† Replies to the questionnaire received, through the respective committee members, from all companies listed above except those designated by a dagger (†). In addition to those listed, information was received also from the Associated Gas and Elec. Co. (western Pa. group) and the Philadelphia (Pa.) Electric Company.

transmission lines. Three replies have been received from companies manufacturing lightning arresters, one from a communication company, and one from a school of electrical engineering.

In abstracting the replies received to these questionnaires, it has been necessary to summarize such data as was uniformly reported in the replies. This has resulted in some loss of detail, but should not affect materially the deductions that can be drawn on the present operating practice of a large cross-section of the industry.

Table I presents a brief summary of the physical characteristics of the systems reported, giving the voltage and miles of transmisson circuits involved together with the method of grounding the various networks. This table shows the predominance of solidly grounded neutral systems, which materially affects the rating of arresters used, and also checks with the report on the grounding practice of transmission systems presented by the subject committee on grounding at the Middle Eastern District meeting of the A.I.E.E. in March 1931, at Pittsburgh, Pa. Twelve of the 17 replies indicate that in general the neutral is grounded at the supply points in each network and 6 of these also indicate grounded neutrals at important load points, particularly on long high voltage lines. Only one company grounds the neutral at practically all supply and load points. Four companies do not indicate where the neutrals are grounded.

Three of the non-operating company representatives express the opinion that from the standpoint of lightning surge voltages which may appear on a system, it does not matter what method is used in grounding the power system; but because of the limitations of present day arresters, it is possible to get better protection with a solidly grounded neutral system where the line to neutral voltage shift on a fault is such as to permit the use of an arrester having a lower rated voltage. One non-operating company considers the ungrounded power system safest, another ventures no opinion.

While the coordination of system insulation has not become general, Table II shows that 7 out of 17 companies are attempting definite relationships of system insulations with 4 more companies having it under consideration, but giving no data. Six companies have made no attempt whatsoever to coordinate insulation. Several state that available test data are not sufficiently reliable or consistent to effect satisfactory coordination of insulation strength.

Three of the non-operating company representatives express the opinion that system insulation within the station should be limited to 2 levels (1) the insulation level of the station apparatus, and (2) the protection level, the line insulation being selected independently. This opinion, of course, is based upon being able to maintain a reliable protection level. One non-operating company suggests that the sequence of impulse strength from maximum to minimum should be (1) internal insulation of apparatus, (2) apparatus bushings, (3) buses and bus connections, (4) line entrance to station.

Another non-operating company representative suggests (1) internal insulation of apparatus, (2) line insulation (assuming steel towers), (3) bus insulators, (4) apparatus bushings, (5) lightning arresters.

Table III shows the extent and method of system protection used on the various transmission systems reported and indicates a prevailing practice of using lightning arresters in approximately 66 per cent of the 1,754 stations reported. In 3.6 per cent of the stations, coordinating gaps are used jointly with lightning arresters and only 1.1 per cent have coordinating alone; some of these installations are experimental. Approximately 30 per cent of the

Questions Contained in the Questionnaire*

1. What is your nominal system voltage between phases for each network system?

2.* Is your system normally ungrounded, dead grounded, or grounded through resistance and/or reactance? Indicate approximate ohmic value, number, and location of grounds on each network system.

3. What is the approximate mileage of 3-phase lines in each network system?

4.* Do you attempt to rationalize or coordinate insulation of various parts, such as line, bus, breaker and transformer bushings, and breaker and transformer interiors? If so, indicate sequence of impulse strength, maximum to minimum.

5.* Do you use some form of coordinating gap or other reduced insulation, other than lightning arresters, at any point on your system? If so, indicate location with reference to terminal apparatus and also relative values of impulse strength. Give number of stations so protected with and without lightning arresters.

6.* Do you use lightning arresters in stations or on lines? If so, give location in feet of arrester from other terminal apparatus, and number of stations so protected without gaps.

7. What is the rated line to line arrester voltage that you use?

8.* Are your arrester ground connections separate from or tied to the main station ground? Indicate average length in circuit feet of tap and ground connections and average resistance of ground connections.

9. Give number of stations without any protection from coordinating gaps or lightning arresters.

10. Give types of arresters used, such as auto-valve, thyrite, etc., indicating the manufacturer.

11. What type and what voltage arresters have you installed in the past 3 years?

12.* If you have had failures in arresters purchased during the past 3 years, what in your opinion caused the failures?

13.* Have you had terminal apparatus failures, due to lightning, during the past 3 years when the arresters failed to protect it? Give type and voltage of arresters involved.

14.* Should the voltage rating of an arrester be different for a grounded system than for an ungrounded system?

15.* What measures have you taken to prevent arrester failures due to overvoltage from waterwheel runaway and/or similar causes?

16.* Are arresters used in each station, substation, outdoor substation and switching station?

17.* Do you use a disconnecting device with the arrester? If so, is it fused?

18.* Have you noticed that some types of arresters installed during the last 3 years require more maintenance than others? If so, what types of arresters require excessive maintenance?

19.* Do you use a method of testing the arresters by measuring the leakage or charging current under the application of rated voltage from a test transformer or a high voltage megger? An excessive current or a low resistance would indicate a faulty arrester.

20. Are the arresters that you are now using satisfactory? If not, why are you dissatisfied?

21.* Do you believe that the tests called for in the proposed A.I.E.E. Lightning Arrester Standards and Appendix No. 28 are adequate? If not, why are they inadequate or what other tests do you consider necessary?

* Entire 21 questions were submitted to operating power companies; "non-operating" companies were asked to state their recommended practices on questions preceded by an asterisk (*).

stations reported are without any protection. Apparently, the use of lightning arresters is as universal as can be justified economically, while the use of coordinating gaps still is quite limited. Table III indicates also the use of many overvoltage arresters, often line to line voltage rating on solidly grounded neutral systems, in order to cope with overvoltage conditions such as waterwheel runaway. In general, the location of the lightning arrester installation is as close as possible to the equipment to be protected, with as short a tap and ground connections as possible. In all cases except one where the

Table I—Physical Characteristics of Systems (Summary of Replies to Questions 1, 2, and 3)

Company		Voltage Class (Kv) 11.5	*13.8*	23	*34.5*	46	*69*	115	*138*	165	*230*	Total Miles of Line	Remarks
A	Miles		50	500	1,400*	875	875	275**	1,830			5,805	*350–27.5 kv **88 kv
	Grounding		O-R	O-R	O-R	O-R	O-R	O-R	O-R				
B	Miles	94		688	404		190	211	59			1,646	*Part not grounded
	Grounding	O-R		O-R*	O-R		O-R	O-R	O-R				
C	Miles	11*		0.08***	8.87*				8.0*			28*	*Open wire only **20 kv
	Grounding	3-R		O-R	O-R				O-R				
D	Miles	175		600			276					1,051	*3,333-kva and 10,000-kva grounding transformers
	Grounding	X*		3.75-R			63 R						
E	Miles	Practically all classes with large mileages in 13.8, 69, 115 and 138 kv										26,000	
	Grounding	Practically all systems operate with solidly grounded neutrals											
F	Miles	540*			161		438					1,139	*12 kv
	Grounding	O-R			O-R		O-R						
G	Miles	181		127			532*					840	*61.2 kv
	Grounding	O-R					O-R						
H	Miles		1,135		370		161				155	1,821	
	Grounding		4-R, 4-X 7-R, 9.5-X Ungrounded		O-R		O-R				O-R		
I	Miles	278		53			409*					740	*57 kv
	Grounding	1.4-Z		Ungrounded			O-R						
J	Miles		450			154-Y 142-Δ		224*				970	*100 kv
	Grounding		Ungrounded			O-R** Ungrounded**		O-R					**Respectively
K	Miles		365		828*		9.0		165		92	1,459	*26.4 kv
	Grounding		2-R		75-R		O-R		O-R		O-R		
L	Miles	750		141		2,077		1,697		91*		4,756	*154 kv
	Grounding	O-R		O-R		O-R		O-R		O-R			
M	Miles				2,121*				546**			2,667	*24 kv
	Grounding				O-R				O-R				**120 kv
N	Miles	884	23	99		710	206	420		97*		2,439	*154 kv
	Grounding	O-R	O-R	O-R		O-R	O-R	O-R		O-R			
O	Miles		619				458*	626				1,703	*60 kv
	Grounding		Ungrounded				O-R	O-R					
P	Miles						188* 138				70	396	*25 cycles
	Grounding						50-R* O-R 300-X				O-R		
Q	Miles			1,400*		130			397			1,927	*25 kv
	Grounding			18-R		O-R			O-R				
											Grand total	55,387	
											Grand total U.S. (N.E.L.A.)	211,361	

Voltage classes shown in *italic* type are N.E.L.A. preferred ratings.
Note.—O-R indicates solidly grounded but 3-R indicates that 3 ohm resistors are used. X and Z similarly indicate use of a reactor or impedance.

Table II—Coordination of System Insulation (Summary of Replies to Question 4)

Company	Line	Coordinating Gap	Disconnect Switch	Bus	Bushings: Oil Circuit Breaker	Bushings: Transformer	Internal: Oil Circuit Breaker	Internal: Transformer	Remarks
A	As desired	4	3	1	3	3	1	2	In a few cases
E	As desired	4	3	3	2	2	1	1	
F									None at present; under consideration
G									None except on oil circuit breaker and transformers
H	As desired	4	1	1	3	3	2	2	
J									To a limited extent
K	As desired	4	3	3	2	2	1	1	
L	As desired	4	2	2	3	3	1	1	
M 24 kv	*	6	4	1	2	5			*Line Pothead 5 and Station Pothead 3
120 kv		4	2	1	3	3			
P 230 kv	1	5	2	2	4	4		3	Lightning arrester 6
69 kv	1	5	2	2	4	4		3	Lightning arrester 5
Q									Attempt to through 60-cycle flashover values; impulse strength to be studied

Numerals indicate relative impulse strengths, maximum to minimum.
Companies B, C, D, I, N, and O—no plans at present.

Table III—Methods of System Protection Used (Summary of Replies to Questions 5, 6, 7, 8, and 9)

Company	Kind of Protection in Number of Stations: Gaps	L. A.	Gaps and L. A.	None	Total	Rating in Max. Voltage: Gap	L. A.	Location: Gap	L. A.	Lightning Arrester Installation: Tied to Sta. Grd.	Avg Length Connections	Avg Res Ohms	Remarks
A		220	30*		250**	75% of bus	L-G 71% of line	Line entrance	Substation as near apparatus as possible	Yes	20 ft	1/4 to 20	*138 kv system only **Does not include 1,750 small transformer stations of which 1,350 have lightning arrester protection and 400 have none
B	4	40	4		48		L-G	Transformer	Substation	Yes	Varies	Varies	
C		13		1	14		L-G		Line entrance	Yes	20 ft**	1 to 20	*Except indoor lightning arrester **Length of ground connection
D		225			225		L-L		Line* and substation	Yes**	25 ft	4.9 station 29 line	*One pole section from terminal equipment about 125 ft **When mounted on same structure
E	15% mostly 66 kv and above	70% mostly 33 kv and below	5%	10%	100%	75% of bus and apparatus*	L-G**	Line entrance and apparatus	Lines 75 to 300 ft from transformer*	Yes	1–30 ft***	1/4 to 10	*Gaps and/or arresters are located at apparatus without internal coordinated insulation **Also based on overvoltage ***Length of tap
F	1	44	1	8	54	21 in.	L-L	Line entrance	Bus or line 60 ft from equipment	Yes	30 ft	0.1–0.5	
G		38	4	3	45		L-L	1/2 mile from terminal	Substation 12 to 100 ft from equipment	No	22 ft*	16	*Length of tap
H		58	1	37*	96	To protect	L-L** L-G	Transformer	Substation	Yes	1–20 ft***	1 to 5	*36 Fed by underground transmission **To handle overvoltage where neutral may shift ***Length of ground connection
I		13*		54	67		L-L*		Bus or line entrance	Yes			*57-kv system with 73 kv lightning arrester to handle overvoltage
J	2	47*	1	2	52		L-L**	Substation	Station*** 2 to 50 ft from equipment	Yes	5–10 ft****		*No L. A. on H. V. side of 4 stations **To handle overvoltage ***Line entrance on some 13.8-kv substations, 25 to 75 ft from equipment ****Length of ground connections
K	9*	64**		19***	92	42 in.* and 83 in.*	L-L	Line entrance and transformer	Bus	Yes	25 ft	1 to 2	*138- and 230-kv systems only; L. A. on L. V. side of 4 stations **26.4- and 13.2-kv systems only ***Fed by underground transmission
L	1	79	10	291	381*	To protect	L-G**	Line entrance or transformers	Bus and transformers 25 to 100 ft from latter	Yes	25 ft	1 to 5	*11-kv stations omitted **Also based on overvoltage
M		127		33*	160		L-G on 24 kv L-L on 120 kv		Line entrance on 120 kv; one L. A. per bus section on cable entrance and on all cable poles**	Yes	20 ft***	0.1 to 5	*Fed by underground transmission **With less than 4 lines, cable entrance L. A. omitted ***Length of tap
N		69	3*	19	91	135 kv	L-G**	300 and 600 ft from station	Bus and line entrance average 50 ft from equipment	Yes	40 ft***	5	*Fused gaps **Also based on overvoltages ***Length of ground connection
O	3*	40	5*	52	100	80% of transf. on 110 kv; 70% of transf. on 60 kv	L-G except 13 kv; L-L on 13 kv	1 line and 2 transfs. on 110 kv;* 3 60-kv lines	Line entrance at gen. sta. and bus at substa. 30 to 100 ft from equipment	Yes	10 ft**		*1 fused on 110-kv line and 1 fused on transformer **Length of ground connection
P		4	1*	2	7	To protect	L-L	Line entrance	Line entrance less than 100 ft from equipment**	Yes	150 ft	1	*230-kv lines only **40 experimental line arresters installed on one 23-mile 69-kv line
Q		70	2*		72	550 kv	0.8 L-L	Transformer	Line entrances 100 to 200 ft on 132 kv. 20 to 50 ft on 44 kv, 3 to 30 ft on 25 kv from transformers	Yes	10 ft**	2	*Fused 10-in. spheres at 2 132-kv transformers; also grading shields are used on some lines and near 2 substations **Length of ground connection only, practically no tap
Totals (Exclusive of Company E)	20	1,151	62	521	1,754								

L. A.—lightning arrester. L-G—maximum line to ground voltage. L-L—maximum line to line voltage.

lightning arresters are mounted on the same structures, the arrester ground connections are connected to the main station ground to keep the ground resistance as low as possible, usually from 1 to 5 ohms.

All the non-operating company representatives recommended the use of lightning arresters installed as close to the equipment as possible with tap and ground leads together not to exceed 100 ft particularly in the higher voltage classes. All except one recommend connecting the arrester ground to the main station ground in order to obtain as low a resistance as possible and place the arrester directly in parallel with the equipment to be protected. In addition to the lightning arresters, 3 recommend the use of some sort of coordinating gap as a secondary line of defense, and one would recommend the use of a coordinating gap if the ability of the lightning arrester to protect is questionable.

To show the types of arresters installed on the various systems and those installed in the 3 years since June 1929, Table IV was prepared. Although not indicated in the table, practically all voltages and kinds of arresters have been installed within the last 3-yr period, with the exception of electrolytic and gap types.

In order to determine if there are any outstanding failures of lightning arresters or equipment, Table V has been prepared showing the tabulation of equipment that has failed in the past 3 years although protected by lightning arresters. This table shows that the outstanding cause of failure of lightning arresters installed within the 3 years is moisture inside the arrester, indicating more or less mechanical weakness. It is interesting to note also that the failures of arresters installed within the 3 years have been more numerous than failures of apparatus protected by those arresters. While many apparatus failures have occurred during the 3 years, it should be noted that practically all of this equipment has been protected by the older types of lightning arresters. In several cases, it has been noted in the replies that the failure point of the equipment is less than the known protective characteristic of the lightning arresters.

The non-operating company representatives have indicated failures of lightning arresters due to light mechanical construction, leakage of moisture, and overvoltage. Failures of terminal equipment have been attributed to direct strokes, failure to protect by older types of arresters, or improper selection and installation of new arresters.

Fourteen operating company representatives have expressed the opinion that the voltage rating of an arrester should be different for a grounded system than for an ungrounded system, while 2 have expressed the belief that arresters should have a single rating in each voltage class and be capable of operating on either a grounded or ungrounded neutral system with ample protective ability. Four non-operating company representatives considered that sufficiently better protection may be obtained to justify arresters having a lower voltage rating for a solidly grounded system than for a partially grounded or ungrounded system.

Seven operating company representatives reported that arresters with overvoltage ratings were installed in order to prevent arrester-failures from overvoltage caused by waterwheel runaway and/or similar causes. However, one of these companies has decreased the voltage rating and has installed mechanical and voltage trips for the generator field and line breakers also to act on the governor. One of these companies also has installed a voltage limiting device on the generating station voltage regulators to limit overvoltages. Ten companies do not require any such provision. Two non-operating company representatives prefer some control device to limit the overvoltage impressed on the arrester or to increase the rating of the arrester, so that normally the arrester will have a minimum voltage rating to provide better protection. One non-operating company representative recommends no measures to prevent arrester failures from overvoltages, and 2 express no opinion on the question.

Ten operating companies use lightning arresters in 90 per cent or more of their stations, substations, outdoor substations, and switching station fed by open wire transmission, with the exception of 2 companies which limit the use of arresters to low voltages (44 and 26.4 kv). Seven operating company representatives would not recommend the use of arresters in every station because they cannot be justified on account of the additional cost and the lightning hazard. All 5 non-operating company representatives recommend the use of lightning arresters in every station where the lightning hazard and the value of the service or the equipment economically justifies the protection.

Six operating companies use an unfused disconnecting device with the arrester in some locations and not in others, determined mainly by the importance of the location. Eleven operating companies use an unfused disconnecting device with every arrester, with one exception in the 13-kv class; 3 of the 11 companies recommended in addition the

Table IV—Type of Arresters Installed (Summary of Replies to Questions 10 and 11)

Company	Auto Valve	**Crystal Valve	Electrolytic	Oxide Film	Pellet	Thyrite	Misc.
A	X*			X*		X*	
B	X*			X*	X*	X*	
C	X	X*		X	X	X*	X
D	X*		X	X	X*	X*	
E	X*	X		X*	X	X*	
F	X*			X*	X	X*	
G			X	X	X*	X*	
H	X*		X	X*		X*	
I	X			X		X*	
J	X*		X	X*	X*	X*	X
K	X*			X		X*	
L	X*	X*	X	X*	X*	X*	
M	X*			X*	X*		
N	X*		X	X*	X*	X*	
O	X		X	X			
P	X*		X	X		X*	X
Q	X*		X	X		X*	X

*Types installed within the 3 years since June 1929.
**This tabulation covers only 11.5-, 15-, and 18-kv crystal valve arresters.

Table V—Equipment Failures Due to Lightning in the 3 Years Since June 1929 When Arresters Failed to Protect (Summary of Replies to Questions 12 and 13)

Company	L. A. Failures Number	L. A. Failures Cause	Apparatus Failures Number	Apparatus Failures Name	Type of Arresters
A	0		Yes	Terminal apparatus	132-kv station
B	2	Direct hits	Yes	Different types	?
C	0		1	Terminal apparatus	15-kv line*
D	0		2	Disconnect switches	66-kv electrolytic*
			9	Disconnect switches	25-kv station*
			1	Power transformers	66-kv station*
			10	Power transformers	22-kv station*
			3	Oil circuit breakers	37-kv station*
			12	Oil circuit breakers	25-kv station*
			6	Bus supports	37-kv station*
			1	Bus support	22-kv station*
E	Several	Moisture	Several	Terminal apparatus	All types
F	Several	Overvoltage and failure to cut-off	Several	Terminal apparatus	All types
G	0		Yes	Terminal apparatus	66-kv station*
H	0		Few	Failure of arrester to protect terminal apparatus is questionable	34.5-kv station
I	0		0		
J	Few	Arcing grounds	0	Except power transformers	15-kv station?
K	6	Moisture	1	37-kv. O. C. B.	31-kv station*
			3	37-kv O. C. B. bushings	31-kv station*
			2	37-kv transformer bushings	31-kv station*
			4	Bus supports	31-kv station*
			3	37-kv O. C. B. bushings	37-kv line*
			1	37-kv transformer bushing	37-kv line*
			10	Bus supports	37-kv line*
L	Several	Moisture	Several	Terminal apparatus	Line and station*
M	Several	Moisture	0		
	Several	Low capacity			
N	1	Moisture	1	Power transformer	110-kv station*
	Numerous	Inadequate capacity of line type	1	O. C. B. bushing	110-kv station*
			1	Bus and current transformer	66-kv station*
			3	Power transformer	22-kv station*
O	0		1	Power transformer	15-kv station*
P	7	Experimental line type	Several	Bus and bushing flashovers	73-kv station*
	1	Unknown			
Q	Several	Inadequate capacity Overvoltage Moisture Mechanical	3	Major terminal apparatus	132-kv station?

*Arrester installed prior to June 1929.

use of a fuse with the disconnecting device, 2 companies on all electrolytic arresters and the other on arresters of 33 kv and less. Four non-operating company representatives recommend the use of a disconnecting device with the arrester, one of these being a fused device. One non-operating company representative does not recommend a disconnecting device.

Thirteen operating companies have not found that arresters installed during the 3 years since June 1929 require more maintenance than others. Four companies have experienced moisture getting into both station and line type arresters and have had trouble with the inadequate discharge capacity of some line type arresters. None of the non-operating company representatives have observed that recent types of arresters require undue maintenance.

Only 4 out of 17 operating company representatives report testing arresters in service; 3 of these use a megger, one and oil test set; one short circuits the gap at normal voltage. Four of the non-operating company representatives believe that measuring the resistance and the leakage or charging current is not a sufficiently reliable field test for arresters because the results do not indicate the operating condition of the arrester or give any indication of the protection afforded by the arrester.

Seven of the 17 operating companies report that they believe the arresters they are now using are satisfactory for the purposes for which they are intended. The remaining 10 express considerable dissatisfaction with present day arresters: 9 state that the arresters have insufficient protective ability to reduce overvoltages below insulation levels, as indicated by equipment failures; 5 believe that the arresters are not sufficiently moisture-proof, as indicated by inspection and lightning arrester failures; 2 believe that the arresters have insufficient discharge capacity, as indicated by arrester failures; 2 consider lightning arresters too costly for general use, as compared with other protective means such as coordinating gaps, and too costly to justify the saving of tripouts.

Twelve operating company representatives and four non-operating company representatives believe that the tests called for in the proposed A.I.E.E. Lightning Arrester Standards and Appendix No. 28 are the best that can be devised with present knowledge of the art, and that they should be adopted and revised as found necessary. Five operating company representatives do not consider the proposed tests adequate: 3 of these suggest that, although the proposed tests provide a means of comparing lightning arresters of different manufacturers, additional tests should be incorporated to determine the capabilities of the arresters and demonstrate the actual protective abilities of the arresters in service on a system, subject to actual lightning discharges; 2 believe that the proposed tests are adequate as factory tests, but recommendations for field tests also should be made to determine the operating condi-

tion of the arrester in service and what overvoltage the arrester may be subjected to without hazard.

CONCLUSIONS

Whole it is somewhat premature to draw definite conclusions on the satisfactory installation and performance of lightning arresters to obtain the best overall system protection, nevertheless, certain definite trends may be observed. A summary of these observations has been attempted:

1. From a lightning protection standpoint, operation of a power system with solidly grounded neutral predominates because (1) it reduces normal voltage stresses and (2) it therefore permits the application of an arrester of lower voltage rating which will limit abnormal voltage stresses to a minimum. Of course, many other factors also effect the method of neutral operation as covered by the 1931 report of the A.I.E.E. subject committee on grounding.

2. Several companies are attempting in a limited way to coordinate system insulation to the extent of available information although there is some question as to the number of insulation steps necessary in terminal equipment for proper coordination; but it is pretty generally believed that the internal insulation of equipment should be the strongest.

3. Too little information is available regarding the dielectric strength of equipment made and tested in different plants and laboratories to effect proper insulation coordination. In such information as is available there is an evident lack of agreement resulting from the test methods used.

4. With an adequate coordinating gap, supplemented possibly by a lightning arrester, there apparently is a trend toward not more than 2 levels of insulation in terminal equipment, that is, internal and external insulation levels.

5. Lightning arresters are used almost universally, being located as close as possible to the equipment to be protected with tap and ground connections as short as possible, and grounded to the main station ground so as to keep ground resistance as low as possible in the shunt protective circuit and to place the arrester directly in parallel with the equipment. In a few cases coordination gaps have been used either alone or in combination with arresters.

6. Arresters of practically all voltages and types have been installed within the last 3 years, with the exception of electrolytic and gap types.

7. The outstanding cause of lightning arrester failure has been moisture getting into the arrester, indicating mechanical weakness. Also, failures of arresters installed within the 3 years since June 1929 have been more numerous than the failures of apparatus protected by these arresters. Manufacturers already have taken cognizance of this fact and are taking steps to improve arrester construction.

8. Practically all apparatus failures during the 3 years since June 1929, are summarized in Table V, have occurred on equipment protected by the older types of lightning arresters.

9. The protective ratio (ratio of maximum impulse voltage to circuit voltage rating) of the modern type of lightning arrester is so high that increased protection will be obtained with arresters having the lowest line to ground voltage rating permitted by the method of grounding the system neutral.

10. Practically no auxiliary equipment is used to limit overvoltages on lightning arresters, and protection is sacrificed when it is necessary to use arresters of higher than normal voltage.

11. Lightning arresters are recommended quite generally for installation wherever the value of the service or the equipment economically justifies the protection, taking into account the ability of the arrester to protect from the lightning hazard involved.

12. In general, unfused disconnecting devices are used with lightning arresters except where they cannot be justified economically.

13. No reliable field tests have been recommended for testing the operating condition of lightning arresters in service.

14. A small majority have expressed dissatisfaction with modern lightning arresters because they have insufficient protective ability and discharge capacity, are not moistureproof, and are too costly.

15. A large majority believe that the tests called for in the proposed A.I.E.E. Lightning Arrester Standards and Appendix No. 28 are satisfactory for comparative purposes and should be adopted, although tests have been suggested to determine the protective ability and operating condition of the arrester in service.

Electricity in Iron and Steel Production—1932

In spite of the fact that there has been little new construction, numerous developments of electricity in the production of iron and steel were made during the past year. These are outlined in the following report of the Institute's committee on applications to iron and steel production.

IN NO YEAR since electrification gained a foothold in the industry, has there been so little activity in main roll drive equipment. When the industry is operating at 15 per cent of capacity there is no justification for the comparatively large expenditures involved in the installation of new mills. However, periods like the present emphasize the need for reducing costs wherever possible; in many instances expenditures for modernizing auxiliaries have been more than justified even at present production, for the resultant saving.

The main roll drives installed during the year consist of: a 3,000-hp 6,600-volt 60-cycle motor driving a sheet bar mill; a 500-hp 2,200-volt 60-cycle motor driving a 10 in. merchant mill; a 1,000-hp a 600-hp and 2,400-hp d-c motors driving cold roll mills and 1,200-hp and 600-hp motors on cold roll strip mills.

The sheet and tin section of the industry seems to be going through a violent awakening, and has shown much activity, evidenced by the installation of automatic furnace and catcher equipments, cold strip mills, continuous gaging equipment, automatic length measuring apparatus, bright annealing furnaces and so forth.

A considerable number of automatic catcher equipments for sheet mills have been installed. Due to the extremely rapid operating cycle on these devices, requiring the driving motors to reverse up to a maximum of 40 times per minute, it has been necessary to develop special motors and control equipments. The majority of these equipments have employed fan cooled squirrel cage a-c motors, but for some mills adjustable speed, d-c motors have been used.

While automatic catcher equipment for 2-high mills was first introduced a year or 2 ago, automatic and manually controlled equipment was developed this year for the 3-high sheet mills.

In this field the photoelectric tube has been applied in some cases as a limit switch to control the

Full text of the annual report for 1932 of the A.I.E.E. committee on applications to iron and steel production to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933.

Committee on applications to iron and steel production: F. O. Schnure, *chairman;* K. A. Auty, J. J. Booth, F. B. Crosby, Wray Dudley, A. M. MacCutcheon, J. S. Murray, G. E. Stoltz, Wilfred Sykes, H. A. Winne, and R. H. Wright.

automatic operation of the catcher equipment. It has also been used in connection with a pack measuring device consisting of a Selsyn generator geared to the mill and a Selsyn receiver connected to a pointer revolving about a dial to give automatically, a fairly exact indication of the length of a sheet after each pass. This indication permits faster rolling, increases of from 5 to 10 per cent having been reported where adequate heating capacity is available. It also reduces the scrap percentage because it indicates to the roller after each pass, what elongation has been effected during that pass and finally indicates on the last pass, whether or not the pack is long or short.

Catcher motor and control equipment is undergoing continual improvement. Motors can be supplied taped for several combinations of winding producing various values of torque and rates of acceleration and deceleration. When rolling loose packs it is necessary to artificially slow up the rates of acceleration and deceleration of the chain conveyor motors and this can be accomplished either by the above mentioned method of changing the motor winding, through a semipermanent 3-phase resistor in the motor circuit or by a saturable reactor in the common circuit of the 2 chain conveyor motors. Each phase of this reactor will have an a-c and d-c winding and the reactor is designed to develop a high value of reactance when the d-c circuit is open. When either the forward or reverse contactors close, d-c excitation is applied to the reactor. The effective reactance of the reactor then decreases as the direct current builds up in the excitation winding. By varying the strength of this current with an adjustable rheostat, the time of reversal can be readily adjusted from 3 to 10 cycles to allow the maximum speed of reversal without slippage; that is, if a motor ordinarily reverses in 10 cycles this device permits increasing the time from 13 to 20 sec. The chief advantage of the reactor method over the resistor method is that the slow down is readily adjustable.

Automatic tension reels have been applied in wire plants where a squirrel cage motor was designed to operate beyond the peak in the torque curve; that is, as the slip increases the torque from the motor decreases. When the reel is approaching its filled point, the torque delivered from the motor shaft is less at the speed required, than when the reel is partially filled. This condition exists because the windage and friction at the higher speed plus the torque necessary to give the proper tension, requires a higher torque from the motor than that required to maintain approximately the same tension at the lower speed, with the increased lever arm.

The measurement and control of temperature during rolling operations, especially with alloy steels is an important factor in the gage or finish of material. The photoelectric tube pyrometer utilizes the radiation from the hot metal as indications of temperatures above 1,500 deg F. Relay devices can be actuated to perform whatever service is required.

Gear motors, consisting of standard a-c or d-c motors with built-in gear systems have been developed for light runout tables and similar applications. Thrustors, a device for producing straight line motion, continue to find new applications.

"Bell" type electric furnaces have been developed for bright annealing wire and strip of either copper, copper alloys, or steel. Continuous type furnaces for similar purposes have been built for material that represents bulk rather than weight. Atmospheres in either type are of a protective nature to prevent oxidation of the material being heated.

Development continues in the use of high frequency current, on the order of 1,000 cycles, for inductively heating materials for annealing, normalizing, or forging. The probabilities are that this method will gain in favor in the future, as the advantages in this type of heat treating and annealing are exploited.

A great number of devices and developments common to all industry are being used to advantage in the steel industry. Among them are control using gas or mercury vapor hot cathode electronic tubes for resistance welding of the intermittent type; de-ion grids for oil circuit breakers and ordinary safety switches; de-ion air circuit breakers rated as high as 1,200 amp., 7,500 volt, for main roll drives; X ray equipment for radiographic examination of thick sections of metal and numerous others of like importance.

Coated welding electrodes, which are now available in both rod and coiled form, for general as well as certain specific applications, have been improved to secure penetration with a lower current, thus avoiding the "spattering" known as undercutting.

While there has not been a great amount of progress in the exchange of power between steel plants and central stations, the margin between the costs of power generated from the by-product heat from the basic operations of steel making, and power generation by central station steam and hydroelectric facilities, has steadily narrowed. The probabilities for the future are toward the use of all possible available by-product heat in steel heating and treating operations and the purchase of power, rather than the generation of power from the by-product gases, and the purchase of auxiliary fuels for heating and treating operations.

Bibliography

The committee submits a list of papers published by various sources which cover in detail many of the subjects mentioned in this report.

1. Annual Review—Electrical Developments 1931–1932, W. H. Burr. *Iron & Steel Engr.*, June 1932, p. 249–60.
2. Practical Methods for Inductively Heating Solids, E. F. Northrup, *Iron & Steel Engr.*, March 1933, p. 67–82.
3. Main Roll Drive of 30-In.–21-In. Continuous Mill at Bethlehem Steel Co.'s Lackawanna Plant, F. D. Egan and C. B. Huston. *Iron & Steel Engr.*, Feb. 1932, p. 93–101.
4. Symposium on Devices Actuated by Light. *Iron & Steel Engr.*, March 1932, p. 123.
5. Developments in Electric Motors and Magnetic Controllers to Handle Mechanical Processes in Sheet and Tin Mills, G. A. Caldwell. *Iron & Steel Engr.*, May 1932, p. 229–33.
6. Developments in Electrical Equipment for Steel Mills, H. A. Winne. *Iron & Steel Engr.*, Jan. 1933, p. 20–22.
7. Hot Rolling, Cold Rolling, Single Stand Mills, Continuous Mills, A. P. Steckel. *Iron & Steel Engr.*, Jan. 1933, p. 3–8.
8. Electrical Equipment for Steckel Mills, Frank Mohler. *Iron & Steel Engr.*, Jan. 1933, p. 8–11.

Relaying of High Voltage Interconnections

A résumé of relaying of high voltage transmission lines is presented in this article, with particular reference to the factors which must be considered on interconnections. The various types of relays in use are summarized from an operating engineer's point of view and conclusions are drawn. It is shown that the most satisfactory schemes are very expensive and the cheaper schemes are not entirely effective. A theoretical solution is proposed.

By
H. P. SLEEPER
MEMBER A.I.E.E.

Public Service Elec. and Gas Co.,
Newark, N. J.

THE INTERCONNECTION of large power systems by means of high voltage transmission lines has expanded so rapidly in the past 10 years that it no longer involves any major engineering problems in the usual application. This excepts the problem of stability which may or may not be present. The protective relaying of such lines has, however, not become standardized and the number of different schemes in use today indicates that complete agreement has not been reached. Moreover, the economics of the various schemes vary over wide limits. Both phases of the subject are worthy of the engineer's study, and it is the purpose of this paper to discuss the merits of the principal schemes and indicate their comparative economics.

Interconnection Relaying Compared With Ordinary Relaying

The essential differences between the ordinary relaying of intra-system lines and the relaying of interconnection lines between systems may be enumerated as follows. The blocks of power to be transmitted over interconnection lines are usually much larger than over intra-system lines. This alone does not necessarily effect the choice of relay schemes but in combination with the next point it presents a limitation. The second point is that the lines are usually of high impedance, being in the ordinary case long open wire lines with large phase spacings to accommodate the high voltages employed. The stability limits of such lines are critical and this imposes the first definite requirement on the relaying of these lines, namely, that of high speed operation. In this paper it is assumed that high speed circuit interruption of the order of 6 to 8 cycles is supplied where high speed relaying of approximately 2 cycles or less is employed.

The third point of difference is the peculiar conditions imposed on such relays while the systems are oscillating with respect to each other. These conditions may also be present on intra-system lines where various power sources are connected by the system transmission lines, although the magnitudes of such power swings are usually less. The relays should be capable of differentiating between the conditions of power flow caused by faults on the interconnection line, and the power flow caused by hunting between the systems. In the latter case it is most important that the relays remain inoperative since the continuity of the interconnection at this particular time may be most important, as the cause of the swinging may readily have been a case of major trouble on one of the systems and part of its power sources may have been rendered unavailable. Hence it is vital that the interconnection transmission line remain in service to deliver emergency power to the system whose load may now exceed the connected generation. On the other hand the relays on such a line should be capable of detecting power swings which indicate severe out-of-step conditions. When such conditions occur it is usually best for the systems to be separated and the relays should accomplish this.

Requirements of the Ideal Relay Scheme

Hence we may enumerate the requirements of the ideal relay scheme for the protection of an open wire high voltage interconnection transmission line, as they are considered in this article, as follows:

1. The relay scheme shall be inherently selective.
2. The relays shall operate instantaneously (2 cycles or less) when a fault occurs.
3. The relays shall operate simultaneously on the ends of the line.
4. The relays shall be unaffected by swinging conditions between the systems as long as the systems do not become out-of-step, in which case the relays should operate.
5. The relay system should provide protection for both phase and ground faults.

There are a few schemes of relay protection which meet most of these requirements as far as phase to phase faults are concerned and these will be discussed first. The detection of ground faults presents more complications in general. The distance type of phase relay protection will be considered first, not because it is the best scheme available but because it is the one which is probably in most common use on interconnection lines constructed in the last few years.

Distance Relaying

Distance relaying has many inherent advantages to recommend it, such as its feature of automatic

Full text of a paper "Relaying of High Voltage Interconnection Transmission Lines" (No. 33-73) to be presented at the A.I.E.E. summer convention, Chicago, Ill., June 26–30, 1933.

selective operation by fault location, its simplicity, and its low cost. It operates instantaneously for a large proportion of faults on the line. It also provides back up protection, usually in the form of self-contained time element devices which are set into operation by other distance measuring units within the relay. But it cannot be said that distance relay protection meets the high speed requirement since its principle of operation leaves a zone of approximately 15 per cent of the line at the far end for a safety factor in distance differentiation. Faults in this zone are detected by the operation of time delay devices. Therefore it may be said that the distance relay meets the speed requirements only 85 per cent, and the distance relay protection of both ends of a line meets the requirement only 70 per cent, since faults in the two 15 per cent zones are not disconnected instantaneously or simultaneously. For the purpose of discussion it is assumed that the number of faults on a line will be evenly distributed over its length. Hence the measure of the high speed ability of a relay scheme is that percentage of the length of the line on which faults are cleared instantaneously. The writer chooses to set distance relays conservatively with the balance point at 85 per cent of the length of the line. This allows as high as a 10 per cent shifting of the balance point to occur from all causes such as changes in generator schedules, outages of intra-system lines, and equipment and personnel errors, without endangering selectivity.

The time of operation of the distance relay scheme varies from a minimum of 1 cycle in 70 per cent of all fault locations, to a first time zone operation for the remaining 30 per cent of fault locations, the time for the 30 per cent zone being usually a minimum of 20 cycles and frequently higher as conditions dictate. A time of 20 cycles permits a safety factor of 100 per cent when selecting with a 2-cycle relay and an 8-cycle circuit breaker. If fault locations multiplied by operating times could be averaged it might be said that the average operating time of the distance relay scheme is $\frac{(70 \times 1) + (30 \times 20)}{100} = 6.7$ cycles. It might therefore be said that the average operating time of distance relay protection approaches that of a high speed scheme.

Although the distance relay does not usually afford true high speed protection, there is one condition where this limitation is avoided. This is the case, sometimes found in practice, where a high voltage line has transformers at each end and the line circuit breakers are connected in the low voltage sides of the transformers. This makes the transformers a part of the line and their lumped impedances permit the distance relays to be set so that all faults on the line, and in parts of the high voltage windings of the transformers, will cause operation of the instantaneous elements of the relays. This causes all line faults to be cleared instantaneously and simultaneously at both ends.

The instantaneous operation of distance relays over the initial 85 per cent of the line requires that the directional elements of these relays shall be of a high speed nature. This is not difficult of attainment if the fault is not too close to the bus, or if it involves only 2 phases. But a 3-phase fault close to the bus may give a voltage of only 1 or 2 per cent of normal, being mainly the resistance drop in the arc. There is no voltage controlled directional element available which will operate instantaneously under these conditions. It is therefore important, where possible, to take relay potential for the directional elements only from the opposite side of the station power transformers. Thus any feed back through these transformers gives an impedance drop which will increase the voltage on the relay directional elements and speed up their operation.

The economics of this type of protection are very favorable since no special high voltage or low voltage equipment is required and the cost of such an installation compares with that of an installation of standard directional overcurrent relays. An accurate replica of voltage conditions on the high voltage circuit should be supplied to the relays but high voltage potential transformers are not absolutely necessary, as bushing potential devices used for this purpose are in successful operation. (See "Bushings Supply Potential," by H. A. P. Langstaff and P. L. Langguth, *Elec. World*, Nov. 24, 1928, p. 1043–5. Also "Relays Operated From Bushing Potential Devices," by P. O. Langguth and V. B. Jones, *Elec. World*, June 25, 1932, p. 1092–6.)

Distance relays are made today in both the impedance and reactance types and their comparative merits have caused considerable controversy. Theoretically the use of the reactance principle with distance relays on open wire lines offers advantages because of the elimination of any consideration or effect of arc resistance. On the other hand the fact that the reactance relay will operate on normal system load characteristics, namely, small apparent reactance and high apparent resistance, complicates the use of this principle. The introduction of a fault detector relay is the solution of one manufacturer. Another places a minimum reactance pick up on the reactance element such that normal load reactances will not be in the zone of operation. Both of these schemes have disadvantages; the former delays the operation of the relay while the fault detector element operates; and the other causes the relay, by the recommendation of the manufacturer, to be restricted to short line applications.

Each of the 2 types of distance relays has its peculiar advantages. The impedance principle is the simpler since only a consideration of ratios of quantities is concerned because the torque of such a relay is proportional to $I^2 - E^2$. The torque of a reactance relay involves the angle between the current and voltage, being proportional to $I^2 - EI \sin \phi$. This has the distinct advantage that the resistance of the entire fault circuit is eliminated from all calculations. But it complicates the operation of the relay since the angle ϕ may vary during the development of a fault, or after the clearing of a fault when hunting may exist between the interconnected systems. The same may occur for faults on the taps of tapped transmission lines. Such lines offer problems to any type of distance relay since the voltage at either terminal

is not a true measurement of the distance to the fault by reason of the increased voltage drop due to the presence in the tap circuit of the summation currents from the 2 sources.

In the writer's opinion the use of the reactance principle, except on short lines where arc resistance may represent a large factor in fault impedance, does not seem to be as desirable as the simpler impedance principle. Furthermore from a practical standpoint, reactance relays are more difficult to calibrate in service than impedance relays.

Experience with distance relaying shows that undersirable operations sometimes occur due to changes in the quantities presented to the relays. These changes are caused by developments at the fault as time progresses. The original relay interpretations are therefore more apt to give correct distance readings. This suggests the desirability of so modifying the design of distance relays that the original measurements determine the time of operation. This would prevent arc resistance, for instance, from increasing to the point of falsifying the distance measurement of an impedance relay and would thus eliminate the main objection to this relay as applied to the short circuit protection of short lines. On longer lines of the type under discussion such errors are negligible.

The operation of distance relays under conditions of system surging leaves considerable to be desired. The impedance type relay in general seems to offer the better chance of holding the systems together under such conditions since only ratios of currents and voltages are being compared in the relays. But it may give delayed operation for an out-of-step condition for the same reason. The reactance relay will be more sensitive to hunting and should operate readily for out-of-step conditions. It is, however, more apt to trip incorrectly during surging because at one point in the rotation of currents and voltages the relay is measuring system resistance only. The ability to separate interconnected systems during instability at the most desirable geographical point may offer a difficult problem with any type of relaying. Some special form of out-of-step relay is usually the simplest practical answer.

There are 2 schemes which compare directly with the distance relay for the protection of interconnection lines, both of which suffer in comparison of economics but have distinct engineering advantages and some practical disadvantages. The first is pilot wire relaying.

Pilot Wire Relaying

Pilot wire relaying is an old art still somewhat in use but comprising only a small percentage of total system relaying today in this country. Its particular advantages as applied to the protection of interconnection lines are its inherent selectivity and its feature of simultaneous operation at both ends for all locations of faults. The pilot wire relay scheme may be made to meet these 2 requirements perfectly and is the only scheme in common use today of which this is true.

Pilot wire relaying is inherently a high speed scheme and operates in an overall time of 1 to 2 cycles in its most preferred forms.

Another advantage of pilot wire relaying is its ability to operate independently of system conditions such as connected generating capacity and outages of transmission lines. The practical advantage of this phase of any relaying scheme is paramount to the operating engineer. The necessity for special calculations and the resetting of relays for different system set-ups is the bane of the operating man.

A further advantage of pilot wire relaying is its ability to protect for both phase and ground faults, using the same set of relays. This feature is perhaps one of its most desirable characteristics since the range of current values for these 2 types of faults may run as high as 9 to 1 even on a solidly grounded system. These data are a matter of actual record on a large 220-kv interconnection system and were taken from automatic oscillograph records. Some schemes of pilot wire protection, however, use separate phase and ground relays.

The obvious disadvantages of this type of protection are the high initial capital cost, the maintenance cost and the operating hazard of maintaining pilot wires between the terminals of the high voltage line. A further disadvantage of this type of protection is that it usually does not provide inherent back up protection for faults beyond its own terminals and such protection must be supplied in the form of additional relays. All of these features tend to make an installation of pilot wire relays expensive as compared with distance relays, or in general with any other types of protection involving only terminal equipment, with the possible exception of the carrier current scheme.

Some of the more recent schemes of pilot wire protection have innovations which from an engineering standpoint render them inherently superior in their general protective features and economics as compared with the older types of this scheme of protection. Some of these schemes were described in "Relay Systems Utilizing Communication Facilities," by J. H. Neher, published in Electrical Engineering for March 1933, p. 162–8. Such schemes are in effect merely means for comparing relay interpretations at the 2 ends of a line by utilizing the pilot wires for d-c circuits only and for simultaneously tripping the 2 terminal circuit breakers. In another arrangement, sometimes called "transferred tripping," the pilot wires are used to permit a standard relay scheme at either end of the line to trip the other end as well, thus completely disconnecting the line with a relay time equal to that of the faster relay system at either end. In general such schemes are distinctly superior to the a-c pilot wire schemes which usually necessitate low resistance pilot circuits and some of which have large normal electrical losses and require special current transformers.

These points are of particular significance if leased pilot circuits are to be employed since the use of the direct current prevents interference with adjacent communication circuits in the same cable. Only very small values of low frequency alternating current can be transmitted over circuits leased from the

communication companies, and thus a-c pilot wire schemes usually require the installation of special pilot wire circuits.

Another point of practical importance in connection with the use of a-c and d-c pilot wire schemes is that of providing means of insulating the terminal relay equipment from the pilot wires. The latter may operate at, or be raised by ground fault currents to, a higher value of potential above ground than the terminal equipment and protection must be provided. In the case of the a-c scheme it can usually be accomplished rather simply by using insulating transformers. But since this is impossible with the d-c scheme it is usually accomplished by the introduction of insulation between the terminal and line parts of certain relays. It is important that such insulation be provided and a circuit established for the relief of dangerous overpotentials. The necessity for such provisions are among the disadvantages of this scheme of protection. Other disadvantages are maintenance hazards, sometimes aggravated by the maintenance personnel if leased circuits are employed; and the general difficulty of checking such schemes for service, particularly the older types.

It is obvious that the scheme of pilot wire relaying can be designed to meet all the requirements of interconnection relays as regards their performance under conditions of system surging. The scheme will inherently pass through blocks of power and remain inoperative, but if a severe out-of-step condition arises so that an electrical neutral is established between the terminals of the line, the pilot wire scheme may be designed to function as on a line fault. Some schemes of this type require the addition of back up or out-of-step relays to accomplish this.

The use of pilot wire relay protection on long open wire interconnection lines is very uncommon for obvious reasons. For short lines it may not be unduly expensive. For longer lines, even where the use of leased pilot circuits helps reduce the investment, the total cost is usually prohibitive unless the engineering features can be very highly capitalized. It is, however, very pertinent to note that this is the only scheme available today which meets all the requirements of the ideal system of interconnection relaying as defined in this article.

Carrier Current Pilot Relaying

While not yet in broad use the scheme of using the high voltage line as a pilot for high frequency carrier relay currents has proved satisfactory on test and in limited service, and is a type of protection which unquestionably offers an extensive field for future development. At the present time, however, the necessity of using expensive high voltage terminal equipment in the form of wave-traps, coupling capacitors, highly insulated control wiring, vacuum tube control devices and special generators for the tube circuits, all tend to make the scheme undesirable for general use. However, this scheme has nearly all of the inherent advantages mentioned for pilot wire relaying and on lines of considerable length would be certain to prove more economical. It eliminates some of the disadvantages of pilot wire relaying, principally the necessity for the pilot wires themselves and their attendant maintenance difficulties, and in its latest form has all of the primary features of pilot wire relaying.

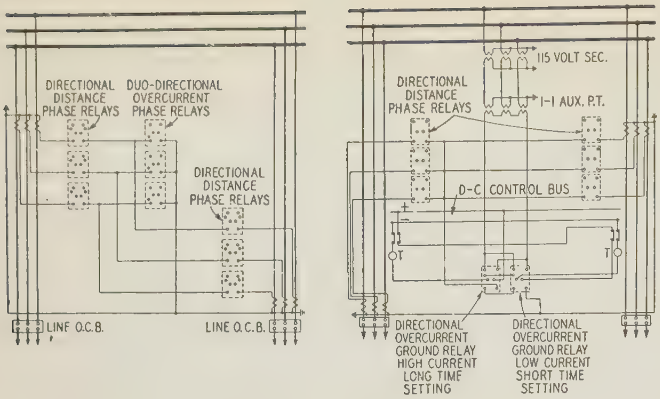
Strictly speaking, this scheme does not come in the class of high speed relaying as previously defined; that is, a scheme which energizes the trip coils of the circuit breakers on both ends of the line in a time of 2 cycles or less after the initiation of the fault. However, effectively it accomplishes almost as rapid total disconnection of the fault from the system, for all possible fault locations, as the pilot wire scheme, and averages faster than the distance relay scheme. The carrier current pilot relay scheme requires a time of 4 to 6 cycles for both circuit breaker trip coils to be energized after the start of the fault condition regardless of fault location. As previously noted, in the most preferred form of pilot wire relaying this time is of the order of 1 or 2 cycles. We have seen that the operating time of distance relay protection varies from 1 to 20 cycles depending upon the location of the fault, and may be said to average 6.7 cycles for all possible fault locations. It therefore seems fair to classify the carrier current pilot relaying scheme as high speed relaying as a matter of practical application, although actually its time of operation is high by 2 or 3 cycles. The manufacturers claim that the overall operating time of 4 cycles of this scheme can be reduced.

The engineering advantages of this scheme of relaying as used on interconnection lines are practically the same as those previously enumerated for pilot wire relaying.

The amount of special equipment at present used with this scheme is the principal disadvantage but its elimination is not an insurmountable engineering problem. The use of vacuum tubes for protective relaying may be questioned by the operating engineer, but one should not fail to recall the extensive use of tubes of this nature in devices much more complicated and operated by laymen. The use of monitoring devices with the tubes renders such an objection practically obsolete. Since the main objection to this scheme of protection is its cost it seems very probable that future developments will be in favor of the extension of this type of protective relaying.

Balanced Relaying of Parallel Lines

Where parallel circuits are used for interconnection lines it is common practice to apply balanced relaying in some form because of its engineering advantages, its general simplicity, and its low cost; also the fact that it can be applied to ground protection as well as to phase protection. However, one should not overlook the fact that single line relaying must be provided also if high speed relaying is desired under all conditions of operation, that is, with either 1 or 2 lines in service. Hence the complete solution may be the initial choice of one of the above described schemes rather than the choice of the balanced scheme for the one operating condition only, the distance relay being preferred for cost reasons if stability conditions permit.



Figs. 1 and 2. Schematic diagrams of parallel line protection

Fig. 1. Duo-directional overcurrent relays for balanced protection and directional distance relays for back up and single line protection. Trip circuit of duo-directional overcurrent relays interrupted when either line oil circuit breaker is open. Potential and trip connections omitted

Fig. 2. Directional overcurrent relays for balanced ground protection and directional distance relays for short circuit protection. Trip circuit of balanced ground relays interrupted when either line oil circuit breaker is open. Potential and trip circuits of distance relays omitted

Fig. 3. Automatic oscillograph record of a 3-phase fault on a 220-kv open wire line

There is, however, one very important engineering advantage to be noted in the use of balanced relaying as compared with distance relaying of parallel interconnection lines. This is the instantaneous sequential operation of the relays on the 2 ends of a line protected by balanced relays, as compared with the instantaneous and first time zone operation of distance relays for all faults occurring in the end zones of such a paired line. The so-called end zone is the 15 per cent of the line beyond the balance point of the instantaneous element of the distance relay. As previously described, when distance relays are used such faults lie within the instantaneous zone of the distance relays on the near end of the line, but require the first time element to operate to clear the far end. Hence the maximum total clearing time on the entire system is that of the time setting of the first time element of one relay, plus an instantaneous relay operation on the other relay plus the operating times of 2 circuit breakers. The minimum time would be that of the first time zone setting plus its circuit breaker and assumes simultaneous operation of the relays at both ends. But with the balanced relay system the total time involved for this location of faults is that of one instantaneous relay plus one circuit breaker on one end, plus one instantaneous relay and its circuit breaker on the other end. This is of course due to the fact that after the first end has cleared, all of the short circuit current is available to unbalance the instantaneous balanced relays at the second end. Hence for all possible locations of faults on one of a pair of parallel lines it may be shown that with either balanced or distance relays approximately 70 per cent of all faults will be cleared by the instantaneous simultaneous operation of the relays on both ends; but with distance relays the remaining 30 per cent of faults will always require the operation of one time element relay and may require the sequential operation of one instantaneous relay plus one time element relay; whereas the balanced relay scheme will clear the remaining 30 per cent of faults in 2 sequential instantaneous relay operations. To all of these relay time values, of course, must be added the clearing times of the circuit breakers. In Table I is shown the comparative operating times of the various schemes.

It is, therefore, obvious that the balanced system of relaying has distinct advantages where it can be applied, as compared with distance relaying. It does, however, have certain practical disadvantages such as the cross connections between current transformers in some cases; the necessity for interlocking the relays with the circuit breakers at the ends of the lines to prevent the tripping of the good line while the faulted line is clearing the second end; and the hazard of tripping a loaded line while switching in the other line of the pair. All of these complications favor the use of the simpler scheme of the distance relays. A scheme to combine the advantages of both and to eliminate some of the disadvantages of each of these schemes is the use of balanced relays for 2-line operation and distance relays for single line operation. (See Fig. 1.) A still simpler scheme is the use of distance relays for short circuit protection and balanced relays for ground protection. (See Fig. 2.) The latter is used on several 220-kv interconnection lines in this country and has been very satisfactory in operation.

The use of balanced relaying for short circuit protection is a very simple and effective solution to the problem of the non-operation of interconnection relays during surging between systems. However, to effect disconnection during out-of-step conditions requires the application of other relays.

Stability Considerations

It is pertinent to consider which of these various schemes of short circuit relay protection can be expected to maintain stability of the interconnected power systems under fault conditions. This question cannot be answered in a general way because each interconnection has individual characteristics. There are interconnections now in operation which by calculation cannot maintain stability if a 3-phase

short circuit exists longer than 3 or 4 cycles. Obviously no protective scheme can accomplish this today when the fastest high voltage circuit breakers available operate in a minimum time of 6 to 8 cycles. But if it is assumed that the fastest relaying scheme available will be satisfactory in this respect, then the comparative abilities of the schemes may be discussed.

As shown in Table I the fastest of the schemes considered operates to clear both ends of the line in a time of 9 cycles and is accomplished by pilot wire relaying. The carrier current scheme of transferred tripping approaches the next closest with a uniform operating time of 10 cycles. The minimum operating times of 2 other schemes are only 9 cycles but their maximum times are considerably higher. Thus both the balanced relay scheme and the distance relay scheme would maintain stability, under the assumed conditions, for 70 per cent of all faults. But in the remaining 30 per cent of cases the clearing time of 18 cycles of the balanced relay scheme might readily cause instability; and the time of 28 cycles of the distance relay scheme would probably be prohibitive in the majority of installations under 3-phase fault conditions. This legitimately raises the question whether the operating time of 12 cycles of the carrier current pilot relay scheme should be conceded as satisfactory. There will unquestionably be cases and conditions where this scheme will not operate fast enough to maintain stability but in the majority of installations it is believed that it will. This discussion also raises the question of using the values of average clearing times as a proper measure of the comparative stabilities to be effected by 2 protective schemes. It can be shown by calculation that an interconnection which might under certain conditions be stable when a fault was cleared in 12 cycles, would be certain to become unstable if the time were extended to 28 cycles. It follows that maximum and not average clearing times should be used for such comparisons.

Frequently an interconnection which cannot be maintained stable during 3-phase short circuits will maintain stability readily during 2-phase, or 1-phase to ground, fault conditions. This may enable the most economical short circuit protective scheme to be applied if the limitations are acceptable. Some cases are on record where short circuit protection has been entirely omitted and only ground relaying provided. Obviously this should not be considered in lightning territory.

Ground Relay Protection

The matter of the ground relay protection of high voltage open wire interconnection circuits is one which may present a difficult engineering problem. Furthermore, it is a most vital one since a very high percentage of all faults on such lines are single-phase to ground. In 3 years of operation on the Pennsylvania-New Jersey interconnection, a total of 82 faults occurred. Of these 73 or 89 per cent were single-phase to ground faults, 4 or 4.9 per cent were 2-phase to ground faults and 5 or 6.1 per cent were 3-phase faults. This number of 3-phase faults shows clearly the necessity for short circuit relay protection on open wire lines in lightning territory. The oscillogram in Fig. 3 shows that ground relays had no opportunity whatever to function on one such fault on these lines.

When the pilot wire or the carrier current relay scheme is used, the problem of ground protection is not always present since these relays may be set to operate for both types of faults unless extremely high values of neutral impedance are used which has not been done in this country to date on lines at the operating voltages considered in this article. With any of the ordinary types of balanced relaying schemes, or any type of distance relaying, a separate relaying scheme for ground faults is mandatory even on solidly grounded systems. This problem has never been satisfactorily solved by a universal scheme other than the use of pilot wire relaying or its equivalent. The use of time element directional ground relays may offer a solution but this is usually not the case with high voltage interconnections as instability may easily be caused by the delayed clearing of a ground fault, although a certain amount of time is usually permissible, the amount varying with the individual case.

A method which has been used with a very acceptable degree of satisfaction is that of a quanti-

Table I—Comparative Operating Times of Various Relaying Schemes Arranged in Order of Maximum Clearing Times

Type of Relaying	Relay Time of One End	Total Relay Time of 2 Ends Min.	Max.	Avg.	Total Clearing Time of Both Ends	Total Time to Clear Fault From System (8 Cyc. Breaker) Min.	Max.	Avg.
Pilot wire scheme	1 cycle	1	1	1	1 cyc. + 1 bkr. opening	9	9	9
Transferred tripping carrier current scheme	2 cycles	2[a]	2	2	2 cyc. + 1 bkr. opening	10	10	10
Carrier current pilot relay scheme	4 cycles	4	4	4	4 cyc. + 1 bkr. opening	12	12	12
Balanced relay scheme	1 cycle	1	10[b]	3.7[c]	1 cyc. + 1 bkr. opening to 2 cyc. + 2 bkr. openings	9	18	11.7
Distance relay scheme	1 or 20 cycles	1	20	6.7	1 cyc. + 1 bkr. opening to 20 cyc. + 1 bkr. opening	9	28 37[d]	14.7

Note: All times are given in cycles.

a. This allows one cycle for line relay plus one cycle for transferred tripping relay.

b. Equals time of relay and breaker at near end plus relay at far end.

c. $\frac{(70 \times 1) + (30 \times 10)}{100} = 3.7.$

d. Equals 1 + 8 + 20 + 8 = 37 cycles possible maximum time for sequential operation of distance relays on parallel lines.

tative measuring scheme which uses either the first or second powers of the zero phase sequence current of the line to determine the location of ground faults. Simple overcurrent relays are used which may be set to operate instantaneously for certain locations of faults, but their zone of safe selective operation is necessarily limited because of the variations in the magnitudes of ground fault currents under various system set-ups. Hence if the scheme can be set to operate instantaneously to disconnect the line for ground faults over 75 per cent of its length from each end it is about all that can be reasonably expected on the average under all conditions of operation. This means, of course, that only 50 per cent of all such faults will be cleared simultaneously and instantaneously at both ends which is rather unsatisfactory when overall system protection is considered. The remaining sections of the line must therefore be protected by time element directional relays and again the prohibitive time feature is introduced. A redeeming feature to the scheme, however, is that a high percentage of faults outside the 50 per cent zone will cause sequential operation of the instantaneous ground relays on the 2 ends of the line due to the resulting increase in current after the first circuit breaker has opened. This may occur in an additional 40 to 50 per cent of possible fault locations, thus giving fairly rapid operation in about 90 or more per cent of all cases. On one installation where this scheme is used, calculations show that 50 per cent of all faults will cause simultaneous operation of the instantaneous ground relays, and sequential operation of the same relays in the remaining 50 per cent of cases. The scheme also has the practical advantage that its very rapid operation for close faults usually permits stability to be maintained on the near system, and the reduced power from the far system frequently permits that end to be cleared with a time delay without resulting in a serious disturbance.

The use of distance relays for ground protection is recommended by the manufacturers and they have been installed to a limited extent in practice. Special current or voltage connections are recommended for such applications and an additional set of relays to those used for phase to phase protection is usually required. An alternative is to use one set of distance relays but to employ an auxiliary fault detector relay to change voltage connections when single-phase to ground faults occur. Reactance type distance relays would seem to lend themselves particularly to this scheme because of the possibility of varying degrees of fault resistance.

Experience with such applications seems to indicate that the complex and variable conditions present at the fault offer a wide range of quantities to the relays. This frequently results in a shifting of the balance point and changing of the power factor of the total fault circuit thus causing erratic operations of the relays for similar fault locations. Faults in the time element zones of the distance relays particularly offer problems due to changes in the fault characteristics with time. In general it cannot be said that the operation of distance relays for ground faults has been very satisfactory to date.

Conclusions

The conclusions which may be drawn are as follows:

1. There is no standard relay scheme available today which meets all the requirements of the ideal scheme which can be universally and economically applied to the protection of open wire high voltage interconnection lines.

2. The pilot wire scheme is the only one which meets all of the engineering requirements of the ideal scheme. Recent schemes of this general type using direct current on the pilot wires have considerably improved these features and lowered the cost of this type of protection. The outstanding engineering disdavantage of this scheme is the hazard of the exposure of the pilot wires themselves. However, it is the most costly of the schemes considered and is therefore usually ruled out of consideration except on applications where no other scheme is possible, or where its engineering advantages may be very highly capitalized. Its future possibilities would seem to be limited.

3. The carrier current pilot relaying scheme, as at present developed, has nearly all of the engineering advantages of the pilot wire scheme and requires only terminal equipment. It has eliminated the outstanding disadvantage of the pilot wire scheme quoted above and while it cannot strictly be classed as a high speed scheme, for all practical purposes it may be so accepted. Its present outstanding disadvantage is its high cost. Its future possibilities seem very promising.

4. The distance relay scheme is a practical compromise which is usually justified because of the present adverse economics of the above schemes. Its outstanding advantages are simplicity and low cost. Its outstanding engineering disadvantages are that its total time of operation cannot be classified as high speed relaying in the usual application; and its operation for ground protection is not entirely satisfactory. Its future applications will probably be numerous by virtue of its comparatively low cost but further developments are needed to perfect this scheme, particularly for ground protection.

5. The general scheme of balanced line relaying, where possible of application, approaches closer to the pilot wire scheme than any other scheme which employs only terminal equipment. The necessity for single line protection modifies these advantages. Also separate ground relays are required. It can be readily combined with other types of relaying and its economics are very favorable. Its future applications will probably be numerous on parallel lines.

6. If the economic as well as the engineering requirements of an ideal scheme are to be considered it is evident that the following would apply: (*a*) The relay scheme shall require the installation of terminal equipment only; (*b*) The relay scheme shall compare in cost with an installation of modern directional overcurrent or directional distance relays.

A Suggested Scheme

A perspective view of the schemes reviewed shows that any 1 of 3 schemes would meet all the ideal requirements both engineering and economic, if at least one main objection could be eliminated from each scheme. The pilot wire scheme is too expensive; the distance relay scheme is too slow; and the carrier current pilot relay scheme is both costly and somewhat slow. It therefore would appear that a theoretical solution would be to combine the desirable features of several schemes and to omit the undesirable features of all. This would seem to be accomplished by using the distance relay for speed and low cost, and extending the zone of operation of its instantaneous element by using carrier current for transferred simultaneous tripping of both terminal circuit breakers.

Therefore, neglecting cost, it is suggested that one theoretical solution of the problem would be the use of a distance relay scheme for short circuit protection, plus an instantaneous directional overcurrent relay scheme for ground protection, plus a carrier current relay scheme for simultaneously tripping

the 2 terminal circuit breakers by the operation of any terminal relay. Such relays could be set to operate instantaneously for faults up to 60 per cent of the length of the line and thus all faults would cause at least one set of relays to operate instantaneously. The scheme of simultaneous tripping would thus cause all faults to be instantaneously and simultaneously disconnected.

It is recognized that the scheme of transferred tripping by carrier current is not yet commercially available.

Electrical Testing of Rubber Covered Wire

An improved method for providing electrical breakdown tests of rubber covered wire has been developed which for telephone wire presents many advantages. The previously used water test has been replaced by a dry test, and one machine combines the testing and coiling operations. Details of the method are presented in this article.

By
C. W. PROTZMAN
NON-MEMBER

W. M. HILL
ASSOCIATE A.I.E.E.

Both of Western Elec Co., Inc., Baltimore, Md.

DEVELOPMENT of a machine for the combined testing and coiling of telephone wire has resulted in a decided reduction in cost without impairment of the product. With this method there has been a reduction in equipment, in floor space, and in scrap losses, and process storage has been eliminated. The testing equipment is of the dry type, the standard water test not being used.

So far as telephone wires are concerned, insulation defects may show up in either of 2 forms:

1. As a complete breakdown.
2. As a low insulation resistance.

The testing equipment described in this article does not apply a direct check on the insulation resistance of the compound, but functions primarily to break down any weak spots in the insulation, and for the purpose of testing telephone wires has been found equal to the standard water test.

Investigations were undertaken several years ago to establish improved methods of manufacture of rubber covered wire for telephone plant. A new and faster method was developed which combined in one continuous operation the rubber insulating and vulcanizing processes. "Straight line" production methods became possible, with the elimination of process stocks and storage; the advantages, however, were reduced by the fact that the standard water test applied to the finished wire required separate testing and coiling. These latter operations therefore appear to offer a fertile field for improvement.

Water Test Previously Used

The usual method for testing telephone wires had been to apply the water test after the weatherproofing process. The water test requires the immersion of the wire to be tested in a water bath for a minimum period of 12 hr before the test is applied. This insures that the entire surface of the insulation is in contact with a conducting medium, and also that the water will have penetrated to the point in the insulation which would be most subject to breakdown or failure in service.

At the end of the immersion period an a-c breakdown voltage is applied for a period of seconds, and following this a d-c insulation resistance test is applied. The first of these locates any points in the insulation which are sufficiently weak to cause breakdown in service, while the second determines whether the resistance of the insulation is sufficiently high to prevent leakage of current that would impair efficiency in service.

In addition to requiring separate testing and coiling or reeling operations, and preventing a continuous flow of material by the necessary delay of

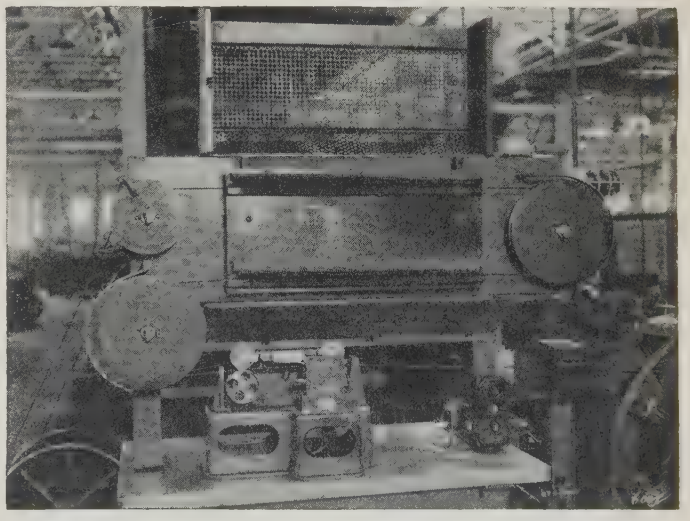


Fig. 1. Spark testing electrode, stop counter, combined wire distributor, and fault locater

Essentially full text of "Electrical Testing in a New Rubber Covered Wire Plant" (No. 32-120) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10-13, 1932.

storing tested wire during drying, the water test requires a relatively large area for equipment and necessitates a large process stock of unfinished wire.

Type of Equipment Adopted

Before starting the development of a new testing process, the field of commercial testing equipment was carefully surveyed to determine whether any existing system could be adopted to meet the requirements of giving an adequate test and at the same time permit straight line production methods to be used. It was found that equipment being introduced in several manufacturers' plants to locate and patch defects at the depanning operations could be modified and developed to fit the need of a plant manufacturing telephone wire.

The equipment as first adopted for testing telephone wire was of the dry or direct testing type which impresses a high a-c voltage upon the outside of an insulated wire whose conductor is grounded. The voltage is impressed upon an electrode approximately 5 ft in length through which the wire passes before being coiled. A weak spot in the insulation therefore results in the formation of an arc from the electrode to the grounded conductor causing a surge and the actuation of control apparatus in the low voltage circuit to stop the passage of the wire and operate audible and visual signals. The overrun of the wire due to the inertia of the supply reel as the solenoid brake is applied carries the defect beyond the electrode to a point where it may be accurately located by means of a hand electrode moved along the wire by the operator.

The high a-c voltage is obtained by means of a specially designed transformer of relatively low power; a condenser in the high voltage circuit raises the commercial 60-cycle frequency to one of several hundred cycles when this circuit is suddenly closed.

Voltages for Testing

The testing transformer of this unit was supplied with secondary voltage taps ranging up to 15,000 volts, and after preliminary trials at various voltages it was determined that the critical voltage for No. 17 bronze parallel drop wire, upon which the tests were being conducted, was between 5,000 and 10,000 volts. No. 17 bronze parallel drop wire consists of 2 insulated No. 17 gage bronze conductors laid in parallel under a single braid of cotton which is impregnated with a standard saturating and a finishing compound. The water test requirements for this wire are as follows:

Breakdown....................	1,000 volts a-c
Insulation resistance (with specified megohms at specified temperatures)......................	500 volts d-c

Tests were, therefore, conducted on the spark tester at the 3 available voltages, namely, 5,000, 7,500, and 10,000 volts. Simultaneously a portion of each day's run of wire was water tested. This insured that the product submitted for each type of test was similar and that the number of defects located by each method would be most nearly comparable. A length of 100,000 ft was arbitrarily set to serve as a basic unit for comparing the relative defects of wire tested by each method.

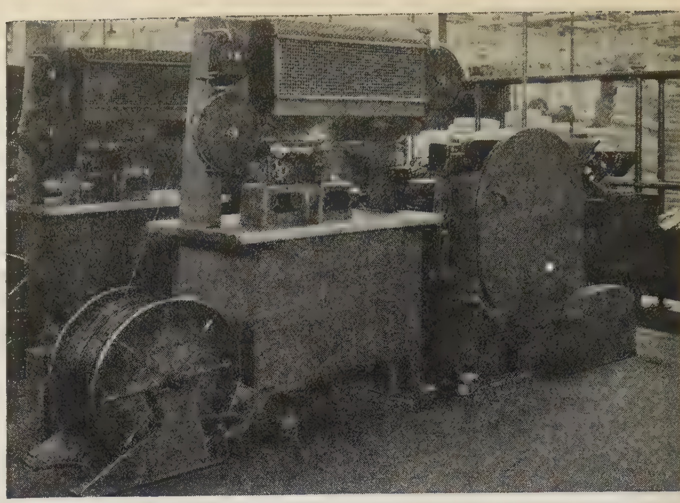


Fig. 2. Relationship of testing and coiling units

Data gathered in these tests indicated that the 7,500-volt tap produced results most nearly comparable to the water test for No. 17 bronze parallel wire, but in order to determine more closely the proper voltage another unit was provided with transformer steps of 1,000 volts, and further tests conducted at 6,000, 7,000, and 8,000 volts, as well as confirmatory checks at 5,000 and 10,000 volts.

The second set of data, based in each case on results from 1,000,000 pair ft of wire or more, indicated that a 7,000-volt spark test located approximately the same number of defects per 100,000 ft of wire as the specified water test, and that a water retest of this spark test resulted in the failure of only 1.65 per cent of the product. This was comparable to a failure of 2.75 per cent of originally water tested wire when subjected to a similar retest, and 7,000 volts was therefore established as the proper spark testing voltage. On this basis the spark test was adopted as standard for the testing of No. 17 bronze parallel drop wire.

It should be noted that the water test was necessary in establishing the proper spark test voltage to insure equally satisfactory insulation resistance and this test will continue to serve in establishing values for any particular type of insulation.

Final Equipment Developed

The adoption of the spark test greatly simplified plans for the layout of a new plant, but due to special features required for testing telephone wire, a number of changes were incorporated to improve the efficiency of operation and to increase the unit output, as well as to further reduce the floor space required. Descriptions of some of the changes which were made follow.

A new electrode was developed incorporating a perforated lower plate or grid, and a pendant chain arrangement. The wire rides in a groove in this

grid and the chain conforms to the upper half of the wire, and being free in vertical movement remains in contact with the wire throughout the entire length of the electrode. The lower slotted member permits loose wax to fall through to a hopper at the bottom of the electrode, the hopper being emptied periodically. This self-cleaning feature insures the correct test voltage being impressed on the wire at all times with a minimum voltage drop due to the collection of wax on the grid.

The electrode was split in half and 2 equal lengths were mounted one above the other with sheaves for reversing the wire, thus reducing the floor area required by approximately one-half. The electric stop counter was placed directly beneath the electrode thus further reducing the amount of space necessary. (See Fig. 1.)

A fault locator built integral with the wire distributor at the coiling head was added in place of the hand locator. The new locator is completely guarded to prevent any possibility of shock to the operator. The present arrangement whereby a system of sheaves permits the placing of the supply stand against the electrode unit, and the electrode unit close to the coiling head, also is shown in Fig. 1.

In order to produce a maximum of tested wire per unit, it was decided that a double coiling head arrangement should be provided so that the operator could tie one coil while another was being tested and wound. The arrangement of 2 heads at either end of an arm which is capable of rotation in a vertical plane, and on which the coiling head in the operating position could be positively engaged with the take-up driving mechanism was finally decided upon. (Figs. 2 and 3 show this mechanism.) Thus the machine automatically coils, measures, and tests wire continuously, save for the short interval required for the operator to rotate the heads and connect the wire to the ground clamp on the coiling head for the next coil.

A control system comprising an arrangement of starting and stopping switches and foot control buttons for releasing the solenoid brakes on supply and take-up mechanisms has been adopted to reduce to a minimum any lost motion on the part of the operator.

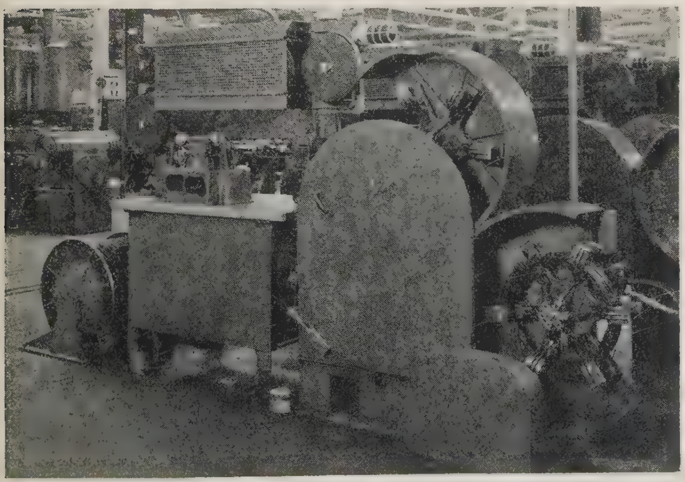


Fig. 3. Two-head coiling arrangement

To provide a foolproof mechanism which would insure that every coil completed was properly tested, the testing circuit and take-up drive mechanism have been electrically interlocked so that it is impossible to rotate the coiling head either by the take-up drive mechanism or by hand, without placing the test voltage on the electrode and fault locator. This is of vital importance in providing a satisfactory test.

In order that the operator may be protected from electrical or mechanical injury, the entire unit has been carefully guarded.

The take-up drive is made inoperative unless the guard over the coiling head is closed; the fault locator is placed in a phenol fiber case which prevents the operator receiving accidental shocks; the electrode is surrounded by a grounded metal guard, and moving members of the drive, as well as solenoid brakes, are properly guarded.

Economic Factors

The elimination of water testing resulted in several major economies. A saving on the original investment was effected which represented a reduction of over 60 per cent in the cost of the testing and coiling equipment. A considerable saving also was effected by the reduction in floor space for testing equipment and also in the elimination of process storage space.

A further saving has been effected through the reduction of scrap losses. Under the old test method it was necessary to first coil the wire into 1,000 ft lengths and then water test it, after which the defective coils had to be removed from the water, dried and recoiled to locate the defect. This resulted in the scrapping of a portion of a large percentage of these coils in which the defect occurred near the end, making the short end too short to meet the minimum length requirement of 200 ft. It also necessitated a second operation which was in itself wasteful as it required special recoiling and testing units. With the new or spark test method the number of short coils which had to be scrapped was greatly reduced, because when a defect occurred it was necessary to cut out only the short section in which the defect occurred and start a new coil. The number of cases where a defect occurred within 200 ft of the start of a coil was measurably fewer, since no predetermined length had to be maintained.

Further Applications

After successfully applying this test to parallel drop wire, we conducted similar tests on twisted, rubber-insulated, and braided wire. The wire in this case was No. 14 hard copper drop wire, which has a 50 per cent heavier insulation than No. 17 bronze parallel drop wire, and is comparable in size to No. 14 code wire. Data were gathered as before, and a satisfactory test voltage established which resulted in the adoption of the spark test for this wire. The voltage was, of course, higher than for the smaller wire, and the success of this experiment indicated the feasibility of spark testing either parallel or

twisted wires of various sizes. It is apparent from the present stage of development of this method of testing that further adaptations are possible which may result in more extensive applications to rubber covered wires throughout the entire wire industry, with commensurate reductions in manufacturing cost.

Abstracts

Of Papers to Be Presented at the Summer Convention

INTERPRETIVE abstracts of all papers definitely scheduled for presentation at the A.I.E.E. summer convention (June 26–30, 1933) are published herewith, excepting only those papers published in this issue of ELECTRICAL ENGINEERING.

Members vitally interested and wishing to obtain a pamphlet copy of any paper available in that form may do so by writing to the A.I.E.E. order department, 33 West 39th Street, New York, N. Y., stating title, author, and publication number of each paper desired. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Testing of High Speed Distance Relays

By E. E. George[1]

HIGH speed distance relays are rapidly establishing a new conception of system protection and are bringing to the front a different technique in relay testing. The inherent speed of distance relays makes it difficult to test them by watching indicating meters and relay motions during operation. Recent improvements in portable oscillographs have increased the utility of such equipment for tests of distance relays and to a lesser extent for tests on the older types of relays.

Most distance relays of recent manufacture depend altogether or largely upon reactance as a measure of distance. This quantity cannot be read directly with indicating meters but is a complex function of current, voltage, and phase angle. The requirements of accurate connections of the relays, both internal and external, are much more exacting than in the case of the older types of relays, and testing of connections is accordingly of major importance.

In making low voltage tests of distance relays it is difficult to duplicate the actual operating conditions. Instead it is customary to test the various component parts of the relays separately and to conclude this analytical test with 2 or 3 overall checks from which the actual operating performance can be deduced. The separate relay elements may be tested under steady state conditions (curves of starting unit pick-up, ohm unit position-reactance curves, etc.) but for an overall check with the relay in motion, it is well to apply the principle of leeway or "safe margin." Of course the time of operation of stepped characteristic relays is indeterminate at the balance points. Operating times may be read at points which are nearer to the relay balance points than those at which the relays are set to discriminate. The minimum operating time may be read at lower values of current and more unfavorable phase angles than those expected during actual operation. By a knowledge of the limitations of various relays, the relay engineer may eliminate many possible causes of subsequent relay operations of a questionable nature.

With the older types such as plain overcurrent relays it is possible to obtain a test which is partly equivalent to an actual system short circuit in 2 steps by reading the relay current under load conditions (relay connection check) and by later passing test current through the relays equivalent to the calculated short-circuit current and reading the operating time of the relays. In the case of distance relays a very complicated set-up of several steps of low voltage tests is required for the synthetic duplication of a very simple short-circuit test. Testing by means of staged short circuits is therefore almost indispensable as an overall installation check of all factors involved, including the constants of the transmission line protected. Where conditions are not exceptionally unfavorable, short-circuit tests usually replace a considerable portion of the low voltage testing which would otherwise be required. Another factor which is increasing the use of short-circuit tests of distance relays is that it is not necessary to make the tests with the normal system connections. Since distance relays are practically independent of generating conditions, the tests may be made with short-circuit current considerably below the normal value and the resulting shock to customers and the system thereby reduced to a minimum. In cases where loads are tapped from or supplied from the end of the circuit to be tested, it has been found quite advantageous to use arcing short circuits with instantaneous reclosing in order to minimize the disturbance to such loads. **(A.I.E.E. paper No. 33-79)**

Relaying of High Voltage Interconnection Transmission Lines

By H. P. Sleeper[2]

(See p. 402–09 this issue.)

Arc Extinction Phenomena in High Voltage Circuit Breakers Studied With a Cathode Ray Oscillograph

By R. C. Van Sickle[3] W. E. Berkey[3]

A MEDIUM-speed cathode-ray oscillograph with a rotating film has been built for the study of circuit breaker transients. The film is wrapped around a drum and rotated in the vacuum at high speed. Each film shows in a continuous trace, a complete story of the formation of arc, subsequent reignitions and final extinction. More than 15 complete cycles may be recorded without excessive blurring. Each film is self-calibrated.

It is the purpose of this paper to describe this instrument used in a study of circuit breaker arc transients around current zero, and to

1. Tennessee Electric Power Company, Chattanooga, Tenn.

2. Public Service Electric and Gas Company, Newark, N. J.
3. Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

discuss the results obtained as applied to circuit breakers. These results may be summarized in the following statements:

1. Arc extinction depends upon the deionization which takes place both before and after the current zero.

2. The effective resistance of the arc space increases in a curve which is a function of the rate of deionization.

3. The effective resistance may become several thousand ohms several microseconds before or after the zero of voltage.

4. The rate of rise of recovery voltage is a function not only of the circuit but also of the circuit breaker.

5. The specifying of certain rates or rise of recovery voltage for circuit breaker testing is not advisable at the present time.

The subject has not been exhausted and it is believed that the continuation of the work will lead to a better understanding of the effect of circuit characteristics on circuit breaker operation. (**A.I.E.E. paper No. 33-80**)

Interrupting Capacity Tests on Circuit Breakers

By R. M. Spurck[4] W. F. Skeats[5]

IMPROVEMENTS in circuit breakers have been accelerated by the availability of short-circuit testing laboratories. Some of these laboratories are of sufficient capacity to test circuit breakers of reasonably high interrupting ratings at their full rated current and voltage. No laboratory, however, has sufficient capacity to make such tests on the largest circuit breakers now used. It has therefore been necessary to study the fundamentals of circuit interruption within the limits of laboratory equipment. Also, much study has been given to the determination of the differences between field service and testing conditions.

These investigations have brought to light many factors that enter into the results and require the weighing of their importance. Among such items are testing technique, characteristics of equipment, circuit connections, power factor, recovery voltage rate, and many others. Some of them have been found to have an important bearing on interrupting duty whereas others may be varied widely within practical limits without changing the results.

So much has been learned about these variables that their effect on interrupting duty can be accurately evaluated and laboratory tests related to field requirements. The combination of these findings with a better understanding of the circuit interrupting problem makes it possible to predict with confidence the performance of most modern circuit breakers at duties considerably beyond the actual short-circuit ability of the laboratory. (**A.I.E.E. paper No. 33-63**)

A Compression Type Low Voltage Air Circuit Breaker

By D. C. Prince[4]

THE totally enclosed fuses employed to protect low-voltage low-current distribution circuits perform their work so effectively and quietly that an analysis has been made to determine their principle of operation in order that this principle might be applied to a small circuit breaker.

Arc drop in general increases with increased pressure. The electrons carrying the current make more and more collisions at which energy and ionization are lost to the arc stream. Due to the more frequent collisions, a greater voltage drop per inch of arc length is required to bring electrons to the potential before collision, at which they can produce new ionization to make up the loss. In an enclosed space, the arc itself will cause the generation of high pressure. When, due to the pressure, arc drop rises to a point where the available voltage can no longer maintain the current, the arc will be distinguished. This principle has been applied to a new small circuit breaker for panelboard applications.

By complete enclosure of the contacts, all noise and flame are effectively prevented from escaping. The circuit breaker is equipped with a thermal overload trip and is also provided with quick make and quick break, overload tripping being entirely independent of the operating lever.

The unit described has a continuous rating of 50 amp at 250 volts with an interrupting capacity rating of 5,000 amp. Larger sizes are being produced which will have continuous ratings as high as 600 amp, 600 volts and interrupting ratings of 10,000 amp or more. (**A.I.E.E. paper No. 33-94**)

Present Practice on Installation and Performance of High Voltage Lightning Arresters for 11-Kv and Above

An A.I.E.E. and N.E.L.A. Subcommittee Report

(See p. 394–400 this issue.)

Compensating Metering in Theory and Practice

By G. B. Schleicher[7]

OUTSTANDING economies can be effected by metering high voltage loads on the low voltage side of the power transformers. A compensating meter in combination with a watthour meter, both connected to instrument transformers on the low voltage side, provides accuracy equal to, and in some cases better than, metering on the high voltage side. The method permits the use of low voltage current transformers of relatively greater thermal and mechanical limits and of improved accuracy, in comparison with high voltage current transformers of relatively smaller current ratings.

In the compensating meter, a voltage-square-hour element and an ampere-square-hour element, together with means for calibrating each in accordance with core and copper losses of a transformer, are combined to give the loss registration in kilowatthours. The method gives absolute assurance that core losses are recorded accurately at times of no load, which is unusual with metering on the high voltage side of step-down transformers. In the combined "load-plus-loss" measurement the effect on accuracy of temperature changes on copper loss measurement and of voltage regulation on core loss measurement is no greater than differences which may occur between the registration of 2 identical commercial high voltage metering installations connected to the same load.

The method provides for a simple measurement of the loss increment of the maximum demand, and also for correcting the results of power factor tests on the low voltage side to the high voltage side of the transformers. When continuous measurement of power factor is required, a compensating meter may be calibrated for reactive kilovoltampere-hours. It is possible also to provide metering as of a remote point on the lines which supply the transformers, by combining the line losses with the copper losses of the transformers.

While the economies of the method are greatest for the higher voltages, in some cases economies have resulted even for relatively small customers' installations supplied at $2{,}300Y/4{,}000\Delta$ volts, with a utilization voltage of 230 volts. In general, these installations would have required 3-element outdoor metering on the high voltage side, while 2-element indoor metering could be installed in existing structures on the low voltage side.

Particular economies result for installations where a customer with a low voltage service rate is changed to a high voltage rate, and the method is advantageous also for metering as of a remote point from the metering installation.

The principles of operation of the compensating meter, test data, and calculated values of transformer and compensating meter characteristics, comparative results for an actual installation, and sample calculations are included. (**A.I.E.E. paper No. 33-87**)

4. General Electric Company, Philadelphia, Pa.
5. General Electric Company, Schenectady, N. Y.
7. Philadelphia Electric Company, Philadelphia, Pa.

A Portable Oscillograph With Unique Features

By K. A. Oplinger[8]

A SIMPLIFIED portable oscillograph having a number of new optical and electrical features is described in this paper. The optical system, which consists of a combination of cylindrical lenses with axes at right angles, is designed to permit simultaneous viewing and photographing. A continuous time axis for both the viewing screen and film is secured by means of a small, variable speed, revolving mirror.

New galvanometers have been developed which have electromagnetic damping instead of the usual oil damping. These galvanometers are very rugged and have been built for recording frequencies as high as 14,000 cycles per sec.

The oscillograph is entirely self-contained and may be operated from a 110-volt 60-cycle lighting circuit without auxiliary attachments. The compactness and portability of the instrument can be seen from its overall dimensions which are 8 in. by $11^1/_2$ in. by 11 in. and from its total weight, which is approximately 18 lb.

Other features which are claimed for this oscillograph are an optical system which magnifies the galvanometer deflections and gives a brilliant trace that can be observed in a brilliantly lighted room; a simple method of taking photographs similar to that in an ordinary camera; a large viewing screen for making tracings or for giving demonstrations to a group of persons; and simplicity, compactness, and ruggedness comparable with the average electrical indicating instrument. Although this oscillograph is a research development product, it will be made available in the near future in a form that will differ only in minor details from the instrument described. **(A.I.E.E. paper No. 33-90)**

Classification of Bridge Methods of Measuring Impedance

By J. G. Ferguson[8]

AN ANALYSIS of the requirements for satisfactory operation of the simple 4-arm bridge when used for impedance measurements is given in this paper. The various forms of bridge are classified into 2 major types called the ratio-arm type and the product-arm type, based on the location of the fixed impedance arms in the bridge. These 2 types are subdivided further, based upon the phase relation which exists between the fixed arm impedances. Eight practical forms of bridges are given, 3 of them being duplicate forms from the standpoint of the method of measuring impedance. These bridges together allow the measurement of any type of impedance in terms of practically any type of adjustable standard. The use of partial substitution methods and of resonance methods with these bridges is discussed and several methods of operation are described which show their flexibility in the measurement of impedance.

The article furnishes a comparison of the relative merits of the large number of circuits which are available for making the same measurement and should serve as a guide to the engineer who is more interested in results than in acquiring a broad education in bridge measurements. An outline is given of the fundamental requirements which must be met by bridges used for impedance measurements, and a classification is made which serves as a help in the choice of a bridge for any particular type of measurement. The relative merits of the simpler types of bridge are discussed from the standpoint of the measurement of both components of an impedance, particularly with reference to measurements in the communication range of frequencies from about 100 to 1,000,000 cycles. Where only the major component of an impedance is desired, for instance where only the inductance of a coil or the capacitance of a condenser is desired, the requirements are not so severe and many forms of bridges may be used which are not suitable for the purpose here outlined. Bridges are also used to a large extent for other purposes than impedance measurements, such as for frequency measurements; these applications are not considered. **(A.I.E.E. paper No. 33-88)**

8. Bell Telephone Laboratories, Inc., New York, N. Y.
9. McGraw-Hill Publishing Company, Inc., New York, N. Y., formerly with the Westinghouse Electric and Manufacturing Company, Newark, N. J.

Better Instrument Springs

By R. W. Carson[9]

ELECTRICAL measuring instruments play an important part in the generation, distribution, and sale of electrical power, and in the development and testing of electrical machinery. The accuracy of electrical measuring instruments depends as much upon the quality of the control springs as on the design of the torque producing elements.

Unstable effects found in the application of spiral springs to electrical instruments arise from aging in service and hereditary hysteresis in the spring material. There is little available information in the technical literature on these effects. In order to produce the most satisfactory spring controlled instruments for the electrical industry, there should be recorded in the technical literature a considerable body of detailed information on springs. Information is needed on such subjects as the effect of composition, condition of material, forming methods, stabilizing treatments, design details, residual stresses, service conditions, and temperature on the performance of spiral instrument springs.

The information presented in this paper resulted from torsional pendulum tests, hardness tests, spring uncoiling tests, various forming and stabilizing treatments, and measurements of hereditary hysteresis with the "grid-glow micrometer."

The results of these tests are presented graphically, showing that moderate temperature heat treatment has an important effect on hereditary hysteresis, that the softening range of cold worked spring ribbon is very critical, that the forming temperature and forming time have a controlling effect on residual stresses, that a stress relief anneal reduces aging and hereditary hysteresis. The nature of the action of hereditary hysteresis is defined.

Additional information is needed on the effect of composition, mechanical condition of the spring material, rolling practice, and the temperature of loading on hereditary hysteresis. Also, the bibliography may not be complete. Discussion on these subjects is invited by the author. **(A.I.E.E. paper No. 33-89)**

The Expulsion Protective Gap

By K. B. McEachron[11], I. W. Gross[12], H. L. Melvin[13]

THE EXPULSION protective gap consists of a fiber tube of proper bore and dimensions so arranged with an internal gap that lightning discharges are conducted within the tube and the power follow current is stopped through the expulsion action of the tube. Its action during interruption of follow current is similar to that of the expulsion fuse. In practice the expulsion gap is provided with a series gap, the whole assembly being electrically in parallel with the insulation to be protected.

On steel tower lines the application is limited to grounded neutral circuits. However, with wood pole lines where the wood insulation of the pole can be utilized, protection of circuits with ungrounded neutral can probably be realized.

Expulsion protective gaps have a maximum and minimum current rating. This means that for proper functioning the device should be chosen so that the phase to phase short circuit current must not exceed the maximum rating while the minimum current to ground should not be less than the minimum rating of the expulsion gap.

Field tests were made on expulsion gaps on the 132-kv system of the Appalachian Electric Power Company at Glen Lyn, Va. Crest currents as large as 6,700 amp were interrupted successfully in $^1/_2$ cycle. One tube interrupted system short circuit current 11 times without showing signs of serious erosion, which indicates that tube life will probably not be limited by the effect of electrical discharges. The tests were entirely successful and indicate that on 132-kv lines expulsion gaps deserve serious consideration as a practical device in rendering a transmission line lightning proof.

11. General Electric Company, Pittsfield, Mass.
12. American Gas and Electric Company, New York, N. Y.
13. Electric Bond and Share Company, New York, N. Y.

Some service experience has been gained with expulsion gaps of an experimental design, principally on the lines of the Arkansas Power and Light Company. All of this experience has been on 110-kv circuits, wood pole H frame construction. The original installation, having had $2^1/_2$ years of service, is credited with 21 successful operations and 2 failures to function. Other installations made since have had varying degrees of success, but considering the limitations of the design of the original installations it can be definitely stated as a result of the field experience that the expulsion protective gap properly developed and applied has indicated great promise for minimizing line tripouts due to lightning. (**A.I.E.E. paper No. 33-64**)

The Deion Flashover Protector and Its Application to Transmission Lines

By
A. M. Opsahl[3]
J. J. Torok[3]

ON POWER transmission lines a flashover due to lightning usually results in a power arc and a line outage. The deion flashover protector, a device intended for the protection of insulation such as used on transmission lines, provides a path for the spark where the resulting power arc can be extinguished without causing a system disturbance. Electrodes within a tube serve as spark and arc terminals. The walls of the tube are made of such material that the arc generates a gas which assists in extinguishing the arc. An external air gap is usually placed between the tube and the line.

This flashover protector can operate a number of times in succession without maintenance. A device requiring the renewal of a fuse would be inoperative in case of a repeated stroke. From photographs of lightning taken with a moving camera it would seem that multiple strokes within a second are quite possible.

Applications must be based upon the surge flashover of the insulation to be protected, the system fault current, and the voltage at which that current must be interrupted.

Although the protector is a relatively new device, it already has had considerable service to demonstrate its practicability. One of the first lines which was equipped with this device was a 110-kv wooden pole line and the protectors were placed at regular intervals. In this case they had several years of service and although called upon to operate many times they have had a perfect record. A more recent application was made on a steel line of 66 kv. This line is 50 miles in length. The majority of line insulators are equipped with protectors. Since this installation has been made no outages have resulted during lightning storms. In another 66-kv application a few of the units have failed mechanically. These units evidently cleared this circuit before failure and did no damage. In this case it was noted that operating conditions were more severe than estimated when the application was made. (**A.I.E.E. paper No. 33-66**)

The Life of Impregnated Paper

By
J. B. Whitehead[14]

IT IS generally agreed that the most important factor limiting the life of the so-called solid type of impregnated paper insulated cable is internal ionization in voids or gas pockets. The much higher stresses in oil filled cables and their exceptional performance in service are commonly attributed to the absence of gaseous ionization. These facts have served to draw increased attention to the question of the type of oil to be used in such cables. The oils for solid cables have been selected from the standpoint of their susceptibility to the formation and ultimate action of internal ionization. With ionization absent, as in the oil filled cable, the question then becomes one of the inherent dielectric and insulating properties of the oil.

The present paper describes a series of accelerated life studies on 14 different oils as used for the impregnation of one grade of paper under conditions of impregnation insuring the complete absence of gaseous ionization. Two striking conclusions are indicated from the studies: first, that there is a definite relationship between the life of impregnated paper under stress, and the capillary constants of the oil as related to the structure of the paper. With oils of a definite type or origin, the life of the paper increases with the penetrative power, which depends upon the surface tension and the viscosity of the oil, and upon the effective capillary radius of the paper. The second general conclusion is that while the foregoing relationship obtains for the oils of any one type or origin, there may be differences in the positions of the curves between penetrative power and life for oils of different types or origins. Thus the studies included 2 groups, the oils in each group having the same origin, one group having a paraffin base and the other having a so-called naphthenic base. The variation of life with penetrative power is of the same type in each group. The curves, however, do not coincide, the naphthene group showing longer life than the paraffin group for the same penetrative power.

During the life runs, measurements were made of dielectric loss, power factor, and dielectric constant. Certain specimens maintained approximately constant value of power factor throughout the successive increases of stress constituting the accelerated life run. Others showed a uniform but moderate increase in power factor and loss. No regular relation is found between life and either the initial values or the subsequent changes in power factor and loss during the life run. In all cases, changes in power factor and loss associated with the approach to breakdown were very large, but were invariably confined to a very short interval at the end of life. Dissection of a number of specimens before breakdown indicated uniform internal conditions after long periods at high stress. The failures were all clean punctures with evidence of moderate gas generation appearing only, however, in the last stages of life. No wax was found in any of the 150 specimens studied. (**A.I.E.E. paper No. 33-72**)

Accelerated Aging Tests on High Voltage Cables and Their Correlation With Service Records

By
D. W. Roper[15]

(See p. 371–7 this issue.)

The Effect of High Oil Pressure Upon the Electrical Strength of Cable Insulation

By
J. A. Scott[5]

IMPROVEMENT in cables, which combine liquid and solid dielectrics, has come largely through the study and control of gaseous electrical phenomena. This is because through circumstances of use in the field, gases enter the cable structure and the resulting electrical discharges in these gas layers cause deterioration ultimately leading to failure. The steps in improvement have successively led first to the abandonment of the heavy solids or petrolatums as treating materials and then to the oil filled cable, where the possibility of entrapped and dissolved gases is reduced to the minimum possible.

Granting, however, that some residual gas remains, its effect should be reduced if we subject it to high pressure, for it is a well-known fact that the breakdown voltage of a gas increases with the pressure almost linearly. Furthermore Koch has shown that the dielectric strength of liquids shows a similar effect but that of solids does not. In order to study the combined dielectric, oil and paper, tests therefore have been made to investigate the effect of high oil pressures on (1) the long time or endurance dielectric strength; (2) the short time

14. The Johns Hopkins University, Baltimore, Md.

15. Commonwealth Edison Company, Chicago, Ill.

dielectric strength; and (3) the impulse voltage strength of treated paper insulation.

Long time overvoltage tests on oil treated cable samples and short time and impulse tests on oil treated paper sheet samples indicate that an increase in the hydrostatic pressure of the oil will result in an increase in the breakdown voltage. The magnitude of this increase depends upon the time duration of the test. A doubling of breakdown voltage was secured by a pressure increase from 1 to 6 atmospheres in the case of the long time (several weeks) while no improvement at all was secured in the case of the impulse tests (several microseconds duration) by a pressure increase up to 11 atmospheres. **(A.I.E.E. paper No. 33-65)**

A New Method of Investigating Cable Deterioration and Its Application to Service-Aged Cable

By
K. S. Wyatt[16]
E. W. Spring[18]
C. H. Fellows[16]

INVESTIGATION of the radial variation in electrical and chemical characteristics of cable insulation between conductor and sheath is suggested as a valuable means for throwing light on cable deterioration in service. A cell is described for the rapid accurate measurement of power factor of individual paper tapes taken from cable. A method is given for determining the total oxidation products in the oil from the paper tapes, layer by layer, from sheath to conductor. The results obtained by applying these methods to several types of service-aged cables are reported, together with the indications which they give of the relative importance of ionization and oxidation as aging factors. The inclusions drawn are as follows:

Deterioration of the insulation of high voltage cables does not take place uniformly in a radial variation between conductor and sheath. The determination of the radial variation of power factor, hydrophil content, and amount of wax is a useful method for determining the origin and nature of deterioration. From limited data, oxidation, probably due to inbreathed air, appears to be a major source of deterioration. Ionization, as indicated by the presence of wax, does not result in sharp increases of dielectric loss. Deterioration of cable occurs during storage, probably due to air that has entered either during the leading process at the factory, or when the cable ends were opened. In service, aging of 3-conductor cables is frequently markedly different on 1 conductor than on the other 2. The radial method promises to have a number of practical applications. **(A.I.E.E. paper No. 33-82)**

Carrier in Cable

By
A. B. Clark [17]
B. W. Kendall[8]

IN ORDER to meet future demands for high-grade and economical circuits in cables, considerable carrier development work has been done which has included an extensive experimental installation on a 25-mile loop of underground cable. Sufficient pairs were provided in the cable and repeaters were installed to set up 9 carrier telephone circuits 850 miles long. Tests on these circuits showed the quality of transmission to be satisfactory, while the methods and devices adopted to prevent interference between them were found to be adequate. The trial has, therefore, demonstrated that the obtaining of large numbers of carrier telephone circuits from cable is a practicable proposition.

This paper is largely devoted to a description of the trial installation and an account of the experimental work which has been done in this connection. Due to present business conditions, it is expected that this method will not have immediate commercial application.

This work is part of a general investigation of transmission systems which are characterized by the fact that each electrical path transmits a broad band of frequencies. Such systems offer important possibilities of economy particularly for routes carrying heavy traffic. The conducting circuit is non-loaded so that the velocity of transmission is much higher than present voice-frequency loaded cable circuits. This is particularly important for very long circuits where transmission delays tend to introduce serious difficulties. **(A.I.E.E. paper No. 33-70)**

Precision Timing of Athletic and Other Sporting Events

By
C. H. Fetter[18]
H. M. Stoller[8]

(See p. 386–91 this issue)

Design Features of the Port Washington Power Plant

By
G. G. Post[19]

AN ANALYTICAL discussion of some of the important decisions reached in the design of the new Port Washington power plant is presented in this paper. This generating station, now under construction, is located on the west shore of Lake Michigan at East Port Washington, Wis., 28 miles north of Milwaukee. The initial section of the station, with one turbine, will have a capacity of 80,000 kw, and will utilize 1,230 lb steam pressure and 825 deg F steam temperature at the throttle, and 825 deg F steam pressure at the reheat point. It will be built on the unit design, one boiler per turbine, one set of transformers, one 132-kv transmission line, and one set of auxiliaries for each unit. The possible ultimate capacity of the station is 400,000 kw in 5 units.

Summaries of certain economic studies which formed the basis for decisions are included, but no statistical information on the various pieces of equipment is given. Among the subjects discussed are selection of site, determination of size, consideration of mercury-steam cycle, selection of 1,200-lb steam cycle, selection of 850 deg F maximum steam temperature, unit design, furnace, heaters and other auxiliaries, selection of 22,000 volts for generation, and selection of switching and auxiliary power equipment. **(A.I.E.E. paper No. 33-68)**

Improvements at Burlington Generating Station

By
W. L. Cisler[2]
W. P. Gavit[21]

THE RECENT development at Burlington generating station of the Public Service Electric and Gas Company of New Jersey is of special interest in these days of stringent economies and efforts to make existing equipment go as far as possible. The station contained 3 12,500-kw turbine-generators from 10 to 16 years old with a stoker fired boiler plant all operating at 200 lb steam pressure with 150 deg superheat; the fuel consumption was 22,000 to 25,000 Btu per kwhr which is about what would be expected with these steam conditions and equipment of that period.

The installation of a high pressure pulverized fuel fired boiler and an 18,000-kw high back pressure non-condensing turbine reduced the station heat rate to about 15,000 Btu per kwhr. As a consequence of this improved economy the Burlington generating station is now prime base load capacity and may be expected to continue in this classification for some years to come.

16. The Detroit Edison Company, Detroit, Mich.
17. American Telephone and Telegraph Company, New York, N. Y.
18. Electrical Research Products, New York, N. Y.
19. The Milwaukee Electric Railway and Light Company, Milwaukee, Wis.
20. W. S. Lee Engineering Corporation, Charlotte, N. C.
21. United Engineers and Constructors, Inc., Philadelphia, Pa.

The reasons leading to the decision to develop this station are given in the paper and the principal features of the equipment selected are described. Particular attention is given to the many auxiliaries. Various changes also were made in the switching equipment and a discussion of these is included.

Shortly after the new installation was put in service, the price of fuel oil receded to a low level and oil burners were inserted through the center of the pulverized coal burners. The change from oil to coal or vice versa may be made in a few minutes and without interruption to boiler operation. Operation of the plant is described, including a record of the failure of the new unit. (A.I.E.E. paper No. 33-76)

The Beauharnois Development of the Soulanges Section of the St. Lawrence River

By W. S. Lee[20]

(See p. 377–84 this issue.)

Transient Torques in Synchronous Machines

By M. Stone[3] L. A. Kilgore[3]

THIS paper determines first the electrical torques due to short circuit as considered from 2 points of view—a machine without losses, and then including losses. The further calculation of the mechanical torques, i. e., shaft and coupling torques, torque reactions in spring mounted machines, etc., shows that the loss torques can result in as serious mechanical stresses as the alternating torque components, though the latter be higher. This is due to the effect of the "transmission factor" discussed in the paper. The calculation of stator stresses shows them to be low, even under a short-circuit torque which is considered to act undiminished because of stator frame rigidity.

The calculated results have been nicely verified by short-circuit tests on a large single-phase spring mounted generator—both the spring torque and inertia torques being recorded.

Two further cases of serious transient torques have been considered: (1) synchronizing out of phase; and (2) allowing a machine to pull out of step and remain connected to the system. In the first case, if the out of phase angle at synchronization were 180 deg, torques 4 times as great as those obtained during short circuit could be created. In the second case, if the slip frequency approaches or coincides with the natural period of oscillation of the mechanical system (as it tends to do), then very serious mechanical stresses are set up, even though the torque frequency is changing with respect to the natural frequency at a relatively rapid rate. (A.I.E.E. paper No. 33-74)

Arc Stability With D-C Welding Generators

By L. R. Ludwig[3] D. Silverman[3]

THE problem of arc stability with d-c welding generators is first analyzed in this paper and the nature of the welding arc is studied. The mechanism of instability is analyzed.

Experimental observations summarized in the paper indicate that instability is not being caused by loss of the cathode spot, but it appears that the cause of instability in the welding arc is an increase in its potential drop due to an increase in losses from the positive column, or possibly an increased cathode fall of potential which does not, however, amount to an actual loss of the essential cathode phenomenon.

Criterions for stability are developed in the form of equations and a test for welding generator stability is described. (A.I.E.E. paper No. 33-92)

Construction Features of Special Resistance Welding Machines

By C. L. Pfeiffer[22]

ALTHOUGH the design of so-called standard resistance welders is more or less fixed, the construction of a special resistance welding machine involves a series of design factors which are only approximate and for which one allows large limits. An attempt is made to outline the elementary features of construction for successful operation by enumerating the factors which must be known. A method of obtaining the proper transformer capacity, types of switches for changing the amount of welding current, and means for regulating the time of application of the current are indicated. Important mechanical conditions to be considered are also touched upon.

This is followed by a description of the construction features of a few outstanding resistance welding machines of special design used at the Hawthorne Plant of the Western Electric Company. Although most of these machines are of relatively small total current capacities, the current densities used are quite high. The machines described are used for welding precious metal contacts, permalloy wire, bronze brushes, switchboard plug parts, and copper rod.

The material presented is intended to be of some help to machine designers who are primarily concerned with mechanical features of design and to whom welding mechanisms and auxiliaries are more or less troublesome. The paper will also serve as a background for products manufacturers in discussing the building or buying of special process welding machines. (A.I.E.E. paper No. 33-93)

Improvements in Mercury Arc Rectifiers

By J. H. Cox[3]

THE PRINCIPLE of building the larger capacity rectifiers in sectional form was discussed in a paper presented before the Institute at the 1932 winter convention. Obviously, the successful achievement of a sectional rectifier, without its becoming prohibitively large, involved the development of a rectifier section much reduced in size from the familiar conventional rectifier of 500 kw to 1,000 kw capacity. Due to the characteristics of the device, this reduction in size of section inevitably resulted in a corresponding reduction in arc drop with a further enhancing of the advantage of the sectional arrangement. The design was based on a 1,250-amp section, which is approximately the rating above which difficulties due to size begin. The 1932 paper briefly described the first design of sectional rectifier. Since that time, considerable improvement has been made both as to performance and convenience of operation. The present paper describes the 2,000-kw 625-volt unit being installated on the Fulton Street line of the independent subway system of the city of New York for the New York board of transportation. This unit is typical for any capacity above 750 kw at 600 volts. The paper also briefly describes smaller rectifiers for capacities below 750 kw.

In addition to describing the improved design of section for the sectional mercury arc rectifier, the paper describes the manner of assembling into the sectional unit. It also includes a brief description of the auxiliaries used. Performance characteristics, which include arc voltage curves, determined from both laboratory tests and operating service, are given. Factors determining design features are discussed. (A.I.E.E. paper No. 33-83)

22. Western Electric Company, Chicago, Ill.

Current and Voltage Wave Shape of Mercury Arc Rectifiers

By H. D. Brown[5] J. J. Smith[5]

MERCURY arc rectifiers have current and voltage wave shapes which are inherent in the normal operation of the apparatus. It is the object of this paper to discuss the wave shape on both the a-c and d-c side of rectifiers and to show how to estimate the wave shapes of the voltage and the current on either side under operating conditions when the circuit constants are known.

The values of the harmonics of voltage and current at light load are considered first and the modifications of the harmonics under load due to impedance are then studied. The results of tests on rectifiers are given and are in reasonable agreement with the theoretical values which, for convenience in use, are plotted in the form of curves. The relation between the harmonics in rectifiers with different transformer connections is shown and consideration is also given to modifications introduced when the a-c voltage contains harmonics or has a phase unbalance. A brief discussion is given of some methods of modifying the harmonic voltages in this type of apparatus.

The data given in this paper apply to rectifiers of the customary types which make use of the rectifying properties of a mercury cathode or a thermionic cathode enclosed in an evacuated chamber. They do not apply to rectifying devices in which the normal operation is controlled by a third element generally called the grid. **(A.I.E.E. paper No. 33-77)**

The Effect of Transient Voltage Protective Devices on Stresses in Power Transformers

By K. K. Palueff[11] J. H. Hagenguth[11]

SHORT time transients such as lightning waves and switching surges cause very high over-voltages in transformers due to high amplitudes of these voltages allowed by transmission line insulation and the non-uniform distribution of such voltages throughout the winding and internal resonance. The internal stresses can be reduced by limiting the amplitude of the impulse waves (gaps and lightning arresters), by changing their shape (wave modifiers), by making voltage distribution uniform throughout the winding irrespective of the shape of the wave (electrostatic shielding of the windings) or by a combination of these means. Coil, turn, and major insulation (except at line end) transient voltages are reduced far more by making the voltage distribution uniform throughout the winding then by reducing the amplitude of the applied wave by any means available at present.

Amplitude control by thyrite lightning arresters reduces voltages depending on the shape of the wave, on grounded systems to between 35 and 60 per cent, on isolated systems to between 43 and 74 per cent, of the maximum allowance of the average line insulation. Maximum reduction is obtained with steep waves. To secure the same protection with spillway gaps (rod gaps, arcing rings, etc.) their setting (particularly for very steep waves) must be made so low that they would arcover at many switching operations. Arcover of spillway gaps produces an abrupt fall in voltage causing high local stresses in windings. A properly designed lightning arrester causes voltage to fall even more gradually than it does in the applied wave. Such an arrester reduces stresses through the entire winding practically in proportion to reduction in the amplitude of the applied wave.

Wave modifiers by slanting the front and tail of the applied wave cause transformer terminal voltages to rise and fall slowly enough to produce more uniform distribution. The shielding produces uniform distribution by neutralizing the undesirable effect of the distributed capacitance of windings. Wave modifiers are essentially of 2 types:

1. Properly designed lightning arresters (like thyrite) shunted with a capacitor.
2. Inductance and resistance in parallel connected in series with the line, combined with a capacitor connected between transformer terminal and ground.

The proper value for electrical constants for a wave modifier can easily be determined where the natural period of free oscillation of the transformer is known. The first type is by far the more practicable of the 2 as it not only modifies the wave but also radically reduces its amplitude. The second type if designed to accomplish the same task becomes quite expensive and bulky.

If it is desired only to attain uniform voltage distribution without materially reducing the amplitude it compares unfavorably with electrostatic shielding. The latter, being internal to the transformer, is more economical and its effectiveness, contrary to that of a wave modifier, is independent of the shape of the applied wave.

Such a modifier is also useless for transformers already installed, as in modern transformers the entire insulation is properly coordinated with station insulation, and therefore they do not need such a modifier, while transformers installed before coordination was generally accepted, require a protective device which substantially reduces the amplitude.

Analysis indicates that necessary values of constants of a wave modifier of the second type that would render substantial protection cannot be economically secured internally in an oil immersed reactor coil placed in a special grounded metal casing. The electrostatic capacitance of such a modifier is too small to be of much value. Extensive tests demonstrated that some common service conditions when duplicated in the laboratory produce higher stresses in the transformer with such a device than without it. **(A.I.E.E. paper No. 33-91)**

The Polarity Factor in the Kindling of Electric Impulse Sparkover Based Upon Lichtenberg Figures

By C. E. Magnusson[23]

THE results of a photographic study of successive steps in the kindling process of impulse-flashover in unsymmetrical dielectric fields are presented in this paper. In order to keep the experimental conditions as simple as possible, the investigation was limited to the initial or kindling stage of impulse-sparkover and the energy content of the impressed potential impulse was kept very small to minimize, as much as possible, the thermionic effects.

The photographs confirm the theory, established by the bending of the electric figure streamers when formed under stress of the magnetic field, that electrons are primarily the active elements in the kindling mechanism. The figures also indicate that in a field of ionizing potential-gradient the bridging of the spark-gap (10.5 cm) is largely due to extension of the streamers or channels from the positive electrode; and that space charges affect the impulse-sparkover process.

The importance of effects due to polarity in high voltage electric phenomena is pointed out in the paper. The experiments made in obtaining this most recent information on the subject are outlined and the equipment used is described. Numerous photographs are included to illustrate the discussion. **(A.I.E.E. paper No. 33-71)**

Progress in 3-Circuit Theory

By A. Boyajian[11]

AFTER some 10 years of experience in the application of "3-circuit theory" to a variety of transformer problems, some limitations are encountered in the application of the elementary theory to certain types of problems. The purpose of this paper is to point out what these limitations are and how they may be circumvented.

In a few words, present theory states that, so far as load characteristics are concerned, each circuit of a 3-circuit transformer may be assigned an individual leakage impedance, and then no explicit thought need be given to any mutual inductive effects between cir-

23. University of Washington, Seattle, Wash.

cuits. Handling of 3-circuit problems is remarkably simplified by this theory. It is generally assumed as applicable to all single-phase and polyphase circuits.

According to the above elementary theory, if 2 secondaries have identical impedances with respect to the primary, their individual leakage impedances will be equal and their simultaneous short-circuit currents will be equal and of the same power factor. Commonsense (uncritical commonsense) also would seem to demand such a conclusion, without any elaborate theoretical arguments. Recent experience has shown, however, that such is not necessarily the case in some polyphase transformers, and that particular attention to symmetry and the balancing of reactances may actually cause a large unbalance in load division. It is further found that such unbalance may change with change in the phase rotation of the excitation. Such anomalous behavior calls for a searching inquiry into the foundations of both theory and commonsense. May it not be that we have generalized too far?

As an example, a transformer with a delta primary, and 2 oppositely zigzagged secondaries, is discussed in the paper and an explanation of the unexpected phenomena which results is given. Although it is not possible to anticipate the infinite variety of possible transformer connections involving interconnection of phases, the following general theorems are suggested:

1. Single-phase 3-circuit equivalent networks and equations are directly applicable to polyphase circuits, provided that there is the same angular displacement between the self and mutual load impedances, as between the normal induced voltages.

2. When there is no cross-connection between phases, the above condition is automatically satisfied; but when such cross-connection exists, the above condition may or may not be satisfied. In at least the simpler symmetrical cases, the impedances may be so designed as to satisfy the above condition.

3. When the condition in paragraph 1 is not satisfied, 3-circuit theory may yet be applied, but to the individual component coils only, to obtain the resultant voltages at the line terminals. (A.I.E.E. paper No. 33-69)

Obtaining Comfort Conditions by Means of Controlled Radiation From Electrically Heated Walls

By L. W. Schad[3]

AT SEDENTARY occupations under normal indoor winter conditions the human body loses heat at the rate of 400 Btu per hr, of which approximately 46 per cent is radiated, 30 per cent is convected, and 24 per cent is lost by the evaporation of moisture from skin and lungs. The skin and clothing surface temperatures average around 80 deg F. With solid surroundings at 80 deg F, therefore, there would be no heat loss by radiation. Any intermediate temperature between the normally prevailing inside wall temperature and 80 deg F would mean a corresponding modification in the amount of heat radiated. Compensation for this decrease in radiated heat may be effected by lowering the air temperature The effect on human comfort of thus controlling the amount of heat radiated from the body is given in this paper. The possibility of using electric energy for this application, together with equipment and operating costs, is also given.

The conclusions drawn in this paper are as follows:

1. The results of observations on space heating with rather extensive surfaces at moderately low temperatures have been worked into a practical method of predicting comfort with various combinations of wall and air temperatures.

2. The air may average from 2 to 8 deg below the average enclosure temperature, resulting in a saving of heat.

3. Most of the radiating surfaces were put in the ceiling, which seems to be desirable to cut down heat losses and is not objectionable from the standpoint of comfort. It would no doubt be desirable to put warm panels in selected places in the side walls such, for instance, as under windows to prevent downward air currents and nullify to some extent at least the body's radiation to the cold window surfaces.

4. A remarkably uniform temperature was found to prevail within the room as a result of the heating method presented in this paper.

5. The low temperature radiant heating method in combination with reversed refrigeration would bring the operating costs of heating electrically down to where it might be competitive with gas and oils or even coal.

6. The watt density varied from 5.3 to 16.1 watts per sq ft. It is possible that a 2-range provision might be made with a density of 50 watts per sq ft for accelerated effects on a cold morning for a few minutes after the power is turned on with a fourth of that density for steady application. Where 1 sq ft of heated area is used for each 10 cu ft of space heated 12.5 watts per sq ft should be ample for quite severe weather. Modifications in outdoor temperature could be taken care of with a thermostat set to throw the power on or off according to requirements. (A.I.E.E. Paper No. 33-78)

Probe Measurements and Potential Distribution in Copper A-C Arcs

By W. G. Dow[24] S. S. Attwood[24] G. S. Timoshenko[24]

SEVERAL articles of recent years have shown the importance of the problem of reignition of a-c arcs in air between copper electrodes. Recently, 2 of the present authors described the conditions controlling the rate of voltage rise across the arc *electrodes* during the interval of cyclic current zero and its relation to the rate of deionization of the gap. The arc reignites if the circuit constants permit the arc electrodes to experience a voltage rise of rapidity sufficient to overcome the growing dielectric strength of the arc space.

The present article shows the distribution of potential *between* the electrodes during the reignition period when the current is zero and emphasizes the possibilities and limitations of probe methods of measurement of this potential distribution.

One or more probes are introduced into the arc space, and by connecting one or another of the probes or the electrodes to a cathode ray oscillograph the changes in potential are recorded that take place in the arc space and near both electrodes during the reignition period.

The first outstanding result of the investigation is that, during the period when the arc current is passing through its cyclic zero and the electrode voltage is changing rapidly and reversing its polarity, the great percentage of the electrode voltage is to be found in a drop in potential at that electrode which is, for the time being, the cathode.

Furthermore, it appears that under appropriate conditions probe methods of measuring the rapidly changing potential distribution are justifiable. (A.I.E.E. paper No. 33-84)

Theory of Primary Networks

By F. M. Starr[5]

THIS paper purports to answer certain pertinent questions in regard to the operation of primary networks under normal and abnormal conditions with particular emphasis on the interrelated effects of voltage regulation, load distribution, and circulating currents. The conclusions offered are substantiated by calculated data, calculating board analyses, and test data on actual systems in operation.

An exact mathematical analysis of the general regulated network is given in the appendix. This analysis is broad in scope and has evident applications other than the particular one with respect to primary networks as considered here.

The particular questions which it has seemed advisable to study in the present paper are as follows:

1. When a transmission line feeding a primary network is taken out of service, how does the load carried by this line distribute among the remaining units?

2. Quantitatively, what advantage in load distribution is gained by staggering the network loads on a given transmission feeder over concentrating adjacent loads on a given feeder?

3. What effect does the automatic regulating equipment (tap-changers or induction regulators) on the network transformers have on the distribution of load under normal and abnormal conditions?

4. Can the compensator used in conjunction with the regulating equipment be adjusted to limit circulating currents (due to differences in tap positions on the network transformers as well as to differences in phase angles of the impressed primary voltages) to a desirable minimum, to aid in uniformly distributing a normally unbalanced load, and at the same time to give adequate over-compounding during peak load?

5. What maximum angular difference between supply voltages to various points in the network is permissible?

6. What procedure should be used in adjusting the compensator to give optimum performance? (A.I.E.E. paper No. 33-85)

24. University of Michigan, Ann Arbor, Mich.

News
Of Institute and Related Activities

Final Announcements for the Summer Convention and Chicago World's Fair

FINAL arrangements for the 49th annual summer convention of the A.I.E.E. to be held at Chicago, Ill., June 26–30, 1933, during Engineers' Week at the World's Fair, have been completed. All planning to attend this convention should register in advance if possible; please fill in and mail the advance registration card which has been sent to you with the mailed announcement. Members and their guests are urged to make their hotel reservations by writing directly to the hotel preferred. Headquarters will be at the Edgewater Beach Hotel, which has excellent hotel facilities, tennis courts, a 9-hole mashie-putting golf course, and a private bathing beach on the shore of Lake Michigan. Those who plan to register at the Edgewater Beach should make their reservations well in advance, as the accommodations are liable to be taxed during the convention on account of the World's Fair.

Westmoreland Country Club near Chicago, Ill., where the golf tournament will be played during the Institute's forthcoming summer convention, June 26–30, 1933. In addition to the golf events for this week announced in ELECTRICAL ENGINEERING for May 1933, golf will include play for the District team championship. Teams will consist of not more than 6, nor less than 4, men. Winner will show lowest gross score for 4 men. If any District has not sufficient golfers present to make up a 4-man team, players may be recruited from other Districts

Technical Sessions

In addition to the technical papers on the program for the summer convention announced in Electrical Engineering for May 1933, p. 343–5, the following papers have been added:

A Compression-Type Low-Voltage Air Circuit Breaker, D. C. Prince, General Electric Co.

Improvements at Burlington Generating Station, W. L. Cisler, Public Service Electric & Gas Co., and W. P. Gavit, United Engineers and Constructors, Inc.

Theory of Primary Networks, F. M. Starr, General Electric Co.

The paper by D. C. Prince has been added to the Tuesday morning session on protective devices; the paper by W. L. Cisler and W. P. Gavit to the Thursday morning session on communication and power generation, and the paper by F. M. Starr to the Friday morning session on electrophysics and related subjects.

On Thursday afternoon, June 29, there will be a joint meeting with the power division of the A.S.M.E. and the hydraulics division of the A.S.C.E. in the grand ballroom of the Palmer House. The meeting will start at 2:15 p.m. with a résumé of the engineering reports on the St. Lawrence power development given by Daniel W. Mead, honorary member A.S.C.E., professor of hydraulic and sanitary engineering, University of Wisconsin, and consulting engineer, Madison, Wis. At 3:15 the discussion will be opened by Thomas H. Hogg, member A.S.C.E. and chief hydraulic engineer of the Hydro Electric Power Commission of Ontario.

The tentative program for the joint meeting with the Econometric Society, The American Society of Mechanical Engineers and the American Society for Testing Materials is announced as follows. The meeting, entitled "Some Fundamental Problems of Mutual Interest to Scientific Economists and Engineers," will be held on Friday afternoon and evening of June 30 at the Palmer House.

2:00 p.m.—Irving Fisher, Yale University; President, Econometric Society; *chairman.*

Contributions of the Mathematician to Economics, C. F. Roos, secretary, Econometric Society. Discussion led by Henry Schultz of the University of Chicago.

The Mathematical Theory of Rational Inference, T. C. Fry, Bell Telephone Laboratories. Discussion led by Harold Hotelling, Columbia University; L. K. Sillcox, vice-president, New York Air Brake Co., and Anson Hayes, director of research, American Rolling Mill Co.

The Engineering Economist of the Future, D. S. Kimball, Cornell University. Discussion led by Harvey N. Davis, president, Stevens Institute of Technology and C. F. Hirshfeld, director of research, Detroit Edison Co.

8:00 p.m.—Meeting continued. Ralph E. Flanders, chairman of committee on relation of consumption, production, and distribution of the American Engineering Council, *chairman;* presidents of the sponsor societies, *honorary chairmen.*

Many Meetings to Feature Engineers' Week at Chicago

Concurrently with the Institute's 49th annual summer convention to be held in Chicago, Ill., June 26–30, 1933, meetings of several other technical organizations will be held. These meetings are an important phase of Engineers' Week at the Century of Progress, Chicago 1933 Exposition. Other organizations holding meetings in Chicago during this week include:

American Association for the Advancement of Science, June 19–30

American Institute of Mining and Metallurgical Engineers, June 26–30

American Society for Testing Materials, June 26–30

American Society of Civil Engineers, June 27–30

American Society of Mechanical Engineers, June 26–30

Econometric Society, June 30

Institute of Radio Engineers, June 26–28

Society for the Promotion of Engineering Education, June 26–30

SOME FUNDAMENTAL PROBLEMS OF THE ENGINEER, F. B. Jewett, American Telephone and Telegraph Co.

THE INTERNATIONALIZATION OF SCIENTIFIC KNOWLEDGE AS A FACTOR IN WORLD ECONOMIC RECOVERY, A. P. M. Fleming, Metropolitan-Vickers Electrical Co.

RAILROAD RATES

Especially low railroad rates for the entire period of the Century of Progress Exposition will be in effect but, as they differ considerably for different starting points, the duration of the stopover period, and the routes traversed, members should consult their local passenger agents for excursion rates to the exposition.

From certain localities it may prove advantageous to form parties to take advantage of the low party rates in effect. Also those who can arrange to leave on Saturday from some points may find that exceptionally low rates are in effect for that day. Consult your local passenger agents in regard to these plans in each case.

1933 Lamme Medal Nominations Due Nov. 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the Lamme Medal, to be awarded in the fall of 1933 may be submitted by any member in accordance with Section 1 of Article VI of the bylaws of the Lamme Medal committee, as quoted in the following:

> The committee shall cause to be published in one or more issues of ELECTRICAL ENGINEERING, or of its successors, each year, preferably including the June issue, a statement regarding the "Lamme Medal" and an invitation for any member to present to the national secretary of the Institute by November 1, the name of a member as a nominee for the medal, accompanied by a statement of his "meritorious achievement" and the names of at least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in cooperation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified above.

The Lamme Medal, founded as a result of a bequest of the late Benjamin Garver Lamme, chief engineer of the Westinghouse Electric and Manufacturing Company (deceased July 8, 1924), provides for the annual award by the Institute of a gold medal—together with bronze replica thereof—to a member of the A.I.E.E. "who has shown meritorious achievement in the development of electrical apparatus or machinery"; and for the award of 2 such medals in some years if the accumulation of funds warrants.

The fifth (1932) Lamme Medal has been awarded to Edward Weston (A'84, M'84, Member for Life and past-president) chairman of the board, Weston Electrical Instrument Corp., Newark, N. J., "for his achievements in the development of electrical apparatus, especially in connection with precision measuring instruments." Presentation will be made during the summer convention at Chicago, Ill., June 26–30, 1933.

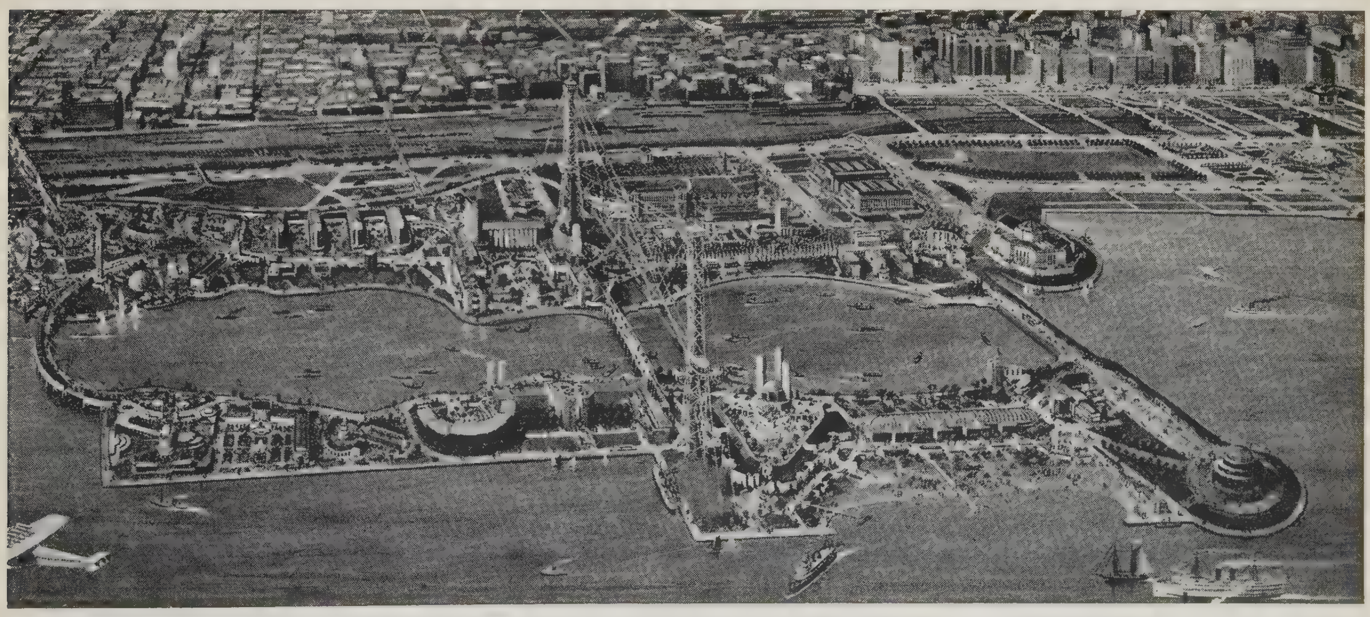
Meeting on Units to Be Held at Chicago

The American Section of the International Union of Pure and Applied Physics will hold a session on the general subject of magnetic and electrical units in Chicago, Ill., June 24, 1933. The meeting will be held at 9:30 a.m., room 133, Eckhart Hall. American and foreign guests are invited.

Dr. R. A. Millikan (M'22) director, Norman Bridge Laboratory of Physics, and chairman of the executive council, California Institute of Technology, Pasadena, is chairman of the International Union of Pure and Applied Physics. Dr. F. K. Richtmyer, chairman of the division of physical science, National Research Council, Washington, D. C., is chairman of the American section of the I.U.P.A.P. The program is announced as follows:

THE BROADER ASPECTS OF THE INTERNATIONAL SYMBOLS, UNITS, AND NOMENCLATURE COMMITTEE'S

Northern Part of "A Century of Progress," Chicago 1933 World's Fair



Looking west toward the mainland, the downtown section of Chicago may be seen in the upper right hand corner of this aerial view. On the mainland of the exposition grounds, from right to left, may be found the aquarium, Soldiers' Field stadium, a tower of the "skyway," hall of science, and general exhibits buildings. On northerly Island, in the foreground is the other tower of the skyway, to the right of which is the U.S. Government building, agricultural building, and planetarium, while to the left of the tower is the hall of social science, the long communication building terminating at its southern end in the semicircular electrical building

ACTIVITIES, Sir Richard Glazebrook, chairman of the international S.U.N. committee.

MAGNETIC UNITS, Henri Abraham, professor of physics at the Sorbonne, and general secretary of the I.U.P.A.P.

MATHEMATICAL CONSIDERATIONS UNDERLYING THE FORMULATION OF THE ELECTRICMAGNETIC EQUATIONS AND THE SELECTION OF UNITS, Leigh Page, professor of physics, Yale University.

A DEFINITIVE SYSTEM OF UNITS, George A. Campbell, American Telephone and Telegraph Company.

THE ESTABLISHMENT AND MAINTENANCE OF THE ELECTRICAL UNITS, Harvey L. Curtis, physicist, U. S. Bureau of Standards.

POSSIBLE EXTENSIONS OF THE EXISTING INTERNATIONAL SERIES OF ELECTRIC UNITS (OHM, VOLT, AMPERE, COULOMB, FARAD, HENRY, JOULE, WATT) INTO A COMPLETE ABSOLUTE SYSTEM, A. E. Kennelly, professor emeritus of electrical engineering, Harvard University.

Directors Meet at Institute Headquarters

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, May 22, 1933.

There were present: *President*—H. P. Charlesworth, New York, N. Y. *Past-presidents*—W. S. Lee, Charlotte, N. C.; C. E. Skinner, Wilkinsburg, Pa. *Vice-presidents*—J. Allen Johnson, Buffalo, N. Y.; W. B. Kouwenhoven, Baltimore, Md.; E. B. Meyer, Newark, N. J. *Directors*—A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New, York N. Y.; A. C. Stevens, Schenectady, N. Y.; R. H. Tapscott, New York, N. Y.; H. R. Woodrow, Brooklyn, N. Y. *National Treasurer*—W. I. Slichter, New York, N. Y. *National Secretary*—H. H. Henline, New York, N. Y.

Approval was given to the minutes of the meeting of the board of directors held January 25, 1933, and to the minutes of the executive committee meeting held March 15, 1933.

A report of a meeting of the board of examiners held May 17, 1933, was presented and approved. Upon the recommendation of the board of examiners, 6 applicants were transferred to the grade of Fellow; 5 applicants were elected, and 7 were transferred, to the grade of Member; 160 applicants were elected to the grade of Associate; 72 Students were enrolled.

The finance committee reported approval, for payment, of monthly bills amounting to $15,595.73. Report approved.

The national secretary reported 3,226 members in arrears for dues for the fiscal year which ended April 30, 1933, and was directed to remove these names from the mailing list after the distribution of the June and July issues of ELECTRICAL ENGINEERING, and to employ the usual methods of collecting the dues and restoring the members to the active membership list.

On account of actions taken by the board of directors in making the necessary reductions in Institute expenditures and in order to provide the flexibility which is essential in such times as the present, the following amendments to the Institute bylaws were adopted:

Sec. 50 was amended to read as follows:

"Sec. 50. The expenditures for transportation of Section delegates as referred to in the constitution, and for all other committees or activities for which such appropriations are provided by the board of directors, shall be paid from the Institute treasury at such rate per mile, one way, from the place of residence to the meeting place, as may from time to time be determined by the board of directors."

Sec. 103 was amended to read as follows:

"Sec 103. An alphabetical and geographical list of members shall be published annually, or at such longer intervals as may be designated by the board of directors. The grade of each member shall be indicated in either list, or both, by a difference in type or otherwise, at the National Secretary's discretion. This list, usually in the form of a year book, shall be sent to any member, without charge, upon receipt of request."

Upon the recommendation of the committee on Student Branches, authority was granted for the organization of a Student Branch of the Institute at South Dakota State College, Brookings.

In accordance with a recommendation of the executive committee of the North West District, it was decided to postpone for one year the Pacific Coast Convention which was to have been held in Salt Lake City in September 1933.

Upon the recommendation of the committee on coordination of Institute activities, a schedule of meetings for the year 1934 was adopted, including the 3 national conventions, namely, the winter convention, New York, January 23–26, the summer convention in June (location to be dicided later), and the Pacific Coast convention, Salt Lake City, in September; no District meetings were scheduled.

It was voted that in connection with national conventions and District meetings a minimum registration fee of $2 be charged non-members in attendance, excepting the wives of members; the proceeds to be used to help defray the convention expenses of trips, entertainment, etc., managed by the local committee.

A report of the technical program committee on a statement of policy and procedure covering the presentation of papers by non-member authors at Institute meetings, was presented and approved.

Upon the recommendation of the standards committee, it was voted that the A.I.E.E. Standard No. 37 (illuminating engineering nomenclature and photometric standards) be withdrawn, inasmuch as it has been superseded by a revision developed by the Illuminating Engineering Society and approved as an American standard by the American Standards Association, and the question of standardization of vacuum tubes for industrial purposes was referred to the electrical standards committee for consideration.

The annual report of the board of directors for the fiscal year ended April 30, 1933, as prepared under the direction of the national secretary, was approved for presentation at the annual meeting of the Institute, in Chicago, June 26, 1933.

The national treasurer presented a report covering the fiscal year just closed, and annual reports were received from the general standing committees (exclusive of the technical committees), abstracts of which were incorporated in the annual report of the board of directors.

A report was presented of the committee on award of Institute prizes on the awards of national prizes for papers presented in 1932 (published elsewhere in this issue).

In accordance with Sec. 37 of the constitution, consideration was given to the appointment of a national secretary for the administrative year beginning August 1, 1933; and National Secretary H. H. Henline was reappointed.

The board ratified the charter and rules of procedure of the Engineers' Council for Professional Development, which was organized in October 1932 in accordance with the plan and procedures approved by the A.I.E.E. and 6 other engineering organizations.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

Pacific Coast Convention Postponed

Acting upon the recommendation of the executive committee of the North West District (No. 9), the Institute's board of directors at its regular meeting May 22, 1933, sanctioned the postponement of the 1933 Pacific Coast convention until 1934. The meeting, originally scheduled for Salt Lake City, Utah, September 4–8, 1933, is now tentatively scheduled for the same place and approximately the same dates next year.

A new program of technical papers, of course, will be developed for the 1934 convention. Since the closing date for the receipt of manuscripts for the proposed 1933 convention was set at June 4, most of the manuscripts originally scheduled for presentation at Salt Lake City this year already have been completed. Subject of course to the usual routine in technical review, and to the action of the publication committee, these papers will be published in ELECTRICAL ENGINEERING and probably also in the TRANSACTIONS. In lieu of the usual opportunity for formal discussion in connection with the presentation of the papers, formal written discussion of the various papers as published may be prepared and forwarded to the Institute's editorial department in the usual way, to receive the usual consideration.

Another Pioneer in Electrical History Passes On

Another reminder of the fact that intimate personal connections with the pioneers of the electrical industry in America are rapidly being severed, is brought to light in the receipt of the notice of the death of C. E. Doolittle (A'95, M'10, F'12, and Member for Life) recorded in the obituary columns of this issue.

It is reported that in the spring of 1887 the Roaring Fork Electric Light and Power Company, of which Mr. Doolittle was the electrical and hydraulic engineer, installed 2 40-kw generators for incandescent lighting in the town of Aspen, Colo., thus making this town the first in America to have its dwelling houses as well as its streets and business houses lighted by electricity from water power. Many original problems had to be solved at that time, one of the most important of which was the controlling of the speed of a waterwheel under great instantaneous load changes and with a high head of water. At the Roaring Fork plant, a head of 876 ft is recorded, and a "differential governor" invented by Mr. Doolittle was used successfully at that and other hydroelectric plants. Many unusual problems in mining engineering, especially as related to hoists, also were solved through the inventive genius of this pioneer.

North Eastern District Holds Ninth Annual Meeting at Schenectady

With a total official registration of 431 persons, the ninth annual meeting of the North Eastern District held May 10–12, 1933, in Schenectady, N. Y., added another to the District's long record of successful meetings. In part, the high registration and the keen interest in the various sessions was due to the efforts of the program committee to include in the program of formal papers more than the ordinary proportion of those dealing with subjects of broad general interest such as aviation and air conditioning, and fewer of those dealing with highly specialized subjects and of correspondingly restricted interest. The relatively central and easily accessible location of Schenectady with respect to the other centers of Institute activity in the North Eastern District also undoubtedly was reflected in the attendance total and diversity. Another inspiring feature of striking strength in connection with the program of the Schenectady meeting was the continuation of the District's aggressive policy of promoting student participation in Institute affairs. The student session at Schenectady drew by far the heaviest attendance of any technical session, and those in attendance were well rewarded for their time.

Technical Program

Aside from minor modifications, the technical program was pursued in accordance with the outline published in the April issue of Electrical Engineering. Officiating at the opening session was E. E. Johnson, chairman of the Schenectady Section, who, briefly welcoming the visitors to Schenectady, wasted no time on formalities, and promptly called upon J. Allen Johnson, Institute vice-president representing the North Eastern District, who addressed the gathering inspiringly on his topic "Professional Advancement—A Reappraisal of the Value of Institute Membership." Mr. Johnson in his theme touched briefly upon some of the many advantages, tangible and intangible, direct and indirect, that accrue to members of the Institute. He emphasized forcefully the 2 thoughts: that the more a member participates in Institute affairs, the greater the member's own selfish return therefrom, and that the possible ratio of return to the individual member is in the approximate order of 15,000 to 1.

Professor Karapetoff of Cornell University, in his scheduled talk "How Are the American Colleges of Engineering to Adapt Themselves to the Changed Conditions in Industry?" urged a drastic, if necessarily gradual, modification in the field of engineering education. Professor Karapetoff's theme was that engineering education has become entirely too closely and directly geared to the technical demands of industry, the meeting of which demand on a "mass production basis" has tended to injure seriously the satisfactory thoroughness of engineering education, whereas a return to the basic concepts of higher education would enable a scientific training with more attention to cultural and sociological developments, resulting in an engineering profession better able to discharge the responsibilities falling upon it through the evolution of society.

Presiding at the various technical sessions were: R. E. Doherty, selected subjects; F. M. Ryan, aeronautics; A. R. Stevenson, Jr., air conditioning; and A. E. Knowlton, reactive power. The session on air conditioning was held at Rice Hall in the engineering laboratories building of the General Electric Company; all other sessions were held in the Van Curler Hotel ballroom.

Student Session

In keeping with the precedent established by the North Eastern District at its previous meetings, an entire technical session was devoted to the presentation of student papers, which session drew an attendance of some 250, the highest of any session. The papers scheduled for presentation were:

Speed Control of D-C Motors With Thyratron Tubes, Lester M. Lang, Rhode Island State College.

An Investigation of Resonance in Non-Linear Circuits, Frank Reintjes, Rensselaer Polytechnic Institute.

The Design of a Pitot Tube for the Measurement of Air Velocities in Electrical Machinery, John P. Gonzals, University of Maine.

Investigation of the Continuous and A-C Characteristics of High Voltage Cables, Eric A. Walker, Harvard University.

Radio Ground-Ray Attenuation Over Limited Distances, Harold F. Lorenz, Worcester Polytechnic Institute.

Instantaneous Recording of Blank Metal Disks, Joseph W. Conn and William Shepherd, Cornell University.

A Study of Mercury Switches, H. L. Anderson and E. L. Angell, Brown University.

A Radio Controlled Model Yacht, R. H. Packard, Harvard University.

An Automatic Voltage Regulator, N. B. Krim, Massachusetts Institute of Technology.

Cosmic Rays, W. P. Overbeck, Massachusetts Institute of Technology.

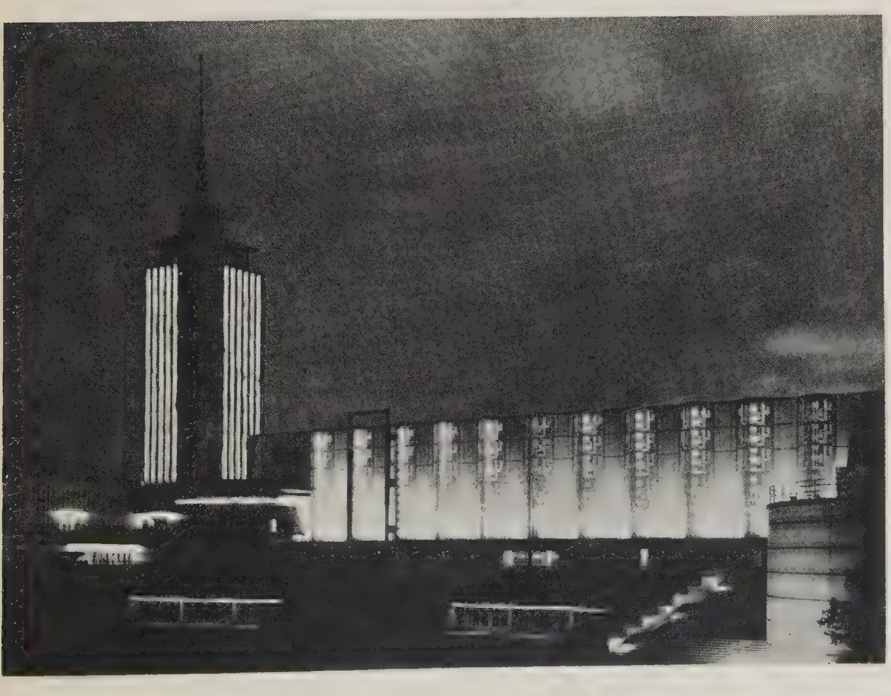
Some Short-Circuit Characteristics of a 3-Kw Transformer, G. E. Signor, Worcester Polytechnic Institute.

A Study of the Telegraphone, C. A. Freeman and N. G. Levesque, Brown University.

Photoelectric Cell Damper Control, H. W. Meminott and H. H. Morefeld, Brown University.

A keen interest was displayed in each of these papers, exemplified by the close attention to the presentations, and the active discussion following. Following their

Hall of Science at the Chicago 1933 World's Fair



presentation, the judges after some difficulty announced the prize winning papers, based on oral presentation only, as:

First, Lester M. Lang, Rhode Island State College.

Second, N. B. Krim, Massachusetts Institute of Technology.

Third, H. L. Anderson and E. L. Angell, Brown University.

An especially valuable feature of the Student sessions held at District meetings was felt to be the contacts which the students could make with engineers.

Entertainment

Inspection trips and entertainment features, both for men and for women, offered a variety of activity very nicely rounding out the meeting program, without crowding it. Special attention was given to entertainment features for women guests, including social affairs Wednesday afternoon at the Hotel Van Curler and Friday afternoon at the Mohawk Country Club, and interesting sightseeing trips to neighboring points of interest. In addition to golf and other entertainment features, special activities for men included luncheon Thursday as the guests of the General Electric Company, and a special luncheon Friday for students and student counselors.

Entertainment affairs designed for both men and women included 2 special demonstrations at Rice Hall and, of course, the annual dinner held Thursday evening at the Van Curler Hotel. In a demonstration at Rice Hall Wednesday evening, a most interesting discourse was delivered by C. W. Stone (A'03, F'12) consulting engineer for the General Electric Company, who outlined a few of the many dramatic steps in the development of talking motion pictures, including references to some of the baffling human and scientific problems involved. Following Mr. Stone's interesting address those in attendance were treated to the first presentation before an Institute body of the first 4 "volumes" of a proposed sound-film record of Institute past-presidents. Appearing in succession on the screen, in monologue and dialogue were Dr. A. E. Kennelly (president 1898–1900), Dr. Elihu Thomson (president 1889–90), E. W. Rice, Jr. (president 1917–18) and Dr. C. F. Scott (president 1902–3). These first 4 films are the outcome of the efforts of one of the 2 groups that have undertaken the recording project, the purpose of which is to secure film records of all living past-presidents of the Institute. Judging by the enthusiasm of those who witnessed this presentation, the work should be carried forward to early conclusion. It is contemplated that the films then will be available through Institute headquarters for use by the various Sections.

The Friday evening demonstration in Rice Hall was given by L. A. Hawkins (A'03, M'13) whose radio dissertations and scientific developments are known to many.

The formal keystone in the figurative entertainment arch was the annual dinner and subsequent dance held Thursday evening. Speakers included J. A. Johnson, District vice-president, and President H. P. Charlesworth, both of whom spoke briefly on Institute affairs. Closing the formal program, A. C. Stevens, secretary-treasurer for the North Eastern District, presented citations and prize awards for 1932 papers presented at Providence District meeting, as follows:

1. Student Branch prize.—Awarded jointly to D. W. Mack for his paper "A Super Heterodyne for Long Distance Television Reception," and to W. S. Bachman and E. M. Wolf for their paper "The Development of a Practical Television Receiver."
2. District first-paper prize.—Awarded jointly to S. B. Crary, Jr. and M. L. Waring for their paper "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances."
3. District best-paper prize.—Awarded to Miss Edith Clarke for her paper entitled "3-Phase Multiple Conductor Circuits."

Registration

The official registration at Schenectady perhaps is more complete than for many other District meetings, a fact contributed to by the elimination of the usual registration fee. In lieu of registration a neat little book of tickets was sold at $2.50 to all those wishing it, providing entrée to all activities including the annual dinner and dance. Supporting something entirely new in the annals of District meetings, the Schenectady book of tickets comprised a small 2-ring vest pocket loose-leaf binder containing an inside cover paster identifying it in connection with A.I.E.E. activities, and including, in addition to blank sheets for convenient note taking, a set of colored printed sheets which served collectively as a convenient reference program of events, and served individually as entrance tickets for events. These tickets were collected only for the dinner and dance, but afforded the opportunity for collection at each of the affairs if it had been desired to have an accurate record of actual attendance.

Total registration figures as finally analyzed revealed the following details concerning attendance:

Student members	150
Student guests	48
Schenectady members	76
Schenectady guests	14
Out-of-town members	112
Out-of-town guests	16
Women guests	15
Total	431

Institute Prize Awards Announced for 1932 Papers

FIVE national prizes for papers presented during the calendar year 1932 have been announced by the committee on award of Institute prizes, which consists of W. H. Harrison (F'31) *chairman*, Chester W. Rice (F'12) and E. B. Meyer (F'27). These prizes in each case consist of a suitable certificate. Personal presentation of the prizes will take place at the opening session of the Institute's summer convention at Chicago, Ill., June 26–30, 1933.

District prizes as announced by 4 Districts include 4 awards of $25 each, together with appropriate certificates. Where there is a joint authorship the cash awards are divided.

National Prizes

Best Papers

Prize for best paper in engineering practice was awarded to K. W. Miller (M'29) and F. O. Wollaston (H'27) for their paper "Thermal Transients and Oil Demands in Cables," presented at the Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

Honorable mention was made of the following papers: "Stability of Conowingo Hydroelectric Station, Philadelphia Electric Company System," by R. A. Hentz (F'29) and J. W. Jones (A'25), presented at the winter convention, New York, N. Y., January 25–29, 1932; and "Generalized Stability Solution for Metropolitan Type Systems," by S. B. Griscom, W. A. Lewis (A'28) and W. R. Ellis (A'25), presented at the winter convention, New York, N. Y., January 25–29, 1932.

Prize for best paper in theory and research awarded to J. B. Whitehead (F'12) and Alfredo Banos, Jr. (A'31) for their paper "Predetermination of the A-C Characteristics of Dielectrics," presented at the winter convention, New York, N. Y., January 25–29, 1932.

Honorable mention was made of the following papers: "The Photoelectric Recorder," by C. W. LaPierre (A'29) presented at the winter convention, New York, N. Y., January 25–29, 1932; "Vertically Cut Sound Records," by H. A. Frederick (F'28) and H. C. Harrison (A'19) presented at the summer convention, Cleveland, Ohio, June 20–24, 1932.

Prize for best paper in public relations and education awarded to R. E. Doherty (M'27) for his paper "Educational Aspects of Engineering and Management," presented at the summer convention, Cleveland, Ohio, June 20–24, 1932.

Honorable mention was made of the paper "Engineering Subjects, Electrical and Cognate, in the 4-Year College Program of Electrical Engineering," by Alfred H. Lovell (M'13) presented at the summer convention, Cleveland, Ohio, June 20–24, 1932.

Initial Paper

Prize for initial paper awarded to S. B. Crary (A'31) and M. L. Waring (A'29) for their paper "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances," presented at the North Eastern District meeting, Providence, R. I., May 4–7, 1932.

Honorable mention was made of the following: "Equivalent Circuits—I," by Frank M. Starr (A'30) presented at the winter convention, New York, N. Y., January 25–29, 1932; "Characteristics of Surge Generators for Transformer Testing," by P. L. Bellaschi (A'29) presented at the summer convention, Cleveland, Ohio, June 20–24, 1932.

Branch Paper

Prize for branch paper awarded to T. M. Austin and F. W. Cooper (A'31) for their paper "The Application of Inductive Non-Linear Circuits to Some Electrical Engineering Problems," presented at the joint meeting of the Denver Section and the University of Colorado Branch, April 29, 1932.

Honorable mention was made of the following papers: "A New Wattmeter for Communication Circuits," by K. R. Eldredge, presented at a joint meeting of the Portland Sections of the A.I.E.E. and N.E.L.A., and the Oregon State College Branch, May 21, 1932; and "A New Method for Measuring Angular Displacements," by Leo Mundell, and W. C. Spear, at a meeting of the University of Colorado Branch, May 18, 1932.

District Prizes

District No. 1

Prize for best paper awarded to Edith Clarke (A'23) for her paper "Three-Phase Multiple Conductor Circuits" presented at the North Eastern District meeting, Providence, R. I., May 4–7, 1932.

Honorable mention was made of the paper "The Solution of Circuits Subjected to Traveling Waves" by H. L. Rorden (A'30), presented at the North Eastern District meeting, Providence, R. I., May 4–7, 1932.

Prize for initial paper awarded jointly to S. B. Crary, Jr. (A'31), and M. L. Waring (A'29) for their paper "Torque Angle Characteristics of Synchronous Machines Following System Disturbances" presented at the North Eastern District meeting, Providence, R. I., May 4–7, 1932.

Prize for Branch paper awarded jointly to the following: D. W. Mack for his paper "A Superheterodyne for Long Distance Television Reception" and W. S. Bachman and E. M. Wolf for their paper "The Development of a Practical Television Receiver," both presented at the North Eastern District Meeting, Providence, R. I., May 4–7, 1932.

District No. 7

Prize for best paper awarded to C. P. Potter (F'29) for his paper "Heating and Overload Protection of Polyphase Motors" presented at St. Louis Section meeting, April 20, 1932.

Prize for Branch paper awarded to B. E. Lowe for his paper "Economics of Rural Line Distribution" presented at the South West District Student Conference, Norman, Okla., October 21, 1932.

District No. 6

Prize for Branch paper awarded jointly to Irwin Olcott and E. R. Gaerttner for their paper "Magnetism and Diamagnetism" presented at Student Night of the Denver Section, April 29, 1932.

District No. 10

Prize for best paper awarded to E. M. Wood (M'25) for his paper "Some Notes on Modern Relay Protection" presented at Toronto Section meeting, November 25, 1932.

Prize for initial paper awarded to E. Geoffrey Cullwick (A'26) for his paper "Theory of the 3-Wire D-C Generator With Two-Phase Static Balancer" presented at Vancouver Section meeting, February 1, 1932, and at Pacific Coast Convention, Vancouver, B. C., August 30–September 2, 1932.

Prize for Branch paper awarded to J. W. McRae for his paper "The Parallel Type Thyratron Inverter" presented at Student Night of the Vancouver Section, May 7, 1932, and at the Pacific Coast Convention, Vancouver, B. C., August 30–September 2, 1932.

Doctor Free Advises Engineers to Be Independent

At the afternoon meeting of the Student Branch convention held in New York, N. Y., April 28, 1933, an address was given by Dr. E. E. Free, consulting engineer and lecturer, on "Outlines of Science" at New York University, in which he stated that the successful business man of the near future will probably be an engineer trained in exactness and fact-finding, but equipped with an adequate knowledge of business methods and systems. Excerpts from Doctor Free's address follow:

"The outlook for engineering graduates is hopeful, but their place in the next business cycle will be quite different than in the past. Depressions usually mark sweeping changes in the conduct of business and college students should be advised to try and see just what changes the present depression is going to impose on the business and industrial structure of the country and to discover, if possible, what opportunities will exist in the next few years.

"The present business situation constitutes, of course, a major depression and business readjustment quite different from any of the fluctuations which we have had in this century. The last approximate equivalent was the depression of the nineties. The last previous to that was the one in the seventies. It really is astonishing to note the substantial parallelism between these 3 depressions. In each instance there was in the beginning an excess of optimism and a feeling that the depression soon would pass. In each instance this was followed by a phase of pessimism, culminating in panic extreme enough to cause a banking crisis. In each instance there has been demand for inflation; yielded to in the seventies with disastrous results, resisted in the nineties but perhaps with no better results. What is happening at present is, of course, the business of a prophet, not of me.

"The chief matter of interest from our viewpoint today is, however, the fact that these major depressions always leave the country with a quite different business world from the one in which they found it. The depression of the seventies started the thing called "big business." The depression of the nineties was the beginning of the present corporate organization in which most of the industrial activity of the country is owned by silent shareholders and managed by elected officials; an industrial system which has been severely criticized during the past few years, probably with justice.

"We are not concerned, however, about the changes which the past depressions brought about. What does concern us is an attempt to foresee, if it be possible at all, some of the changes which the present depression will cause; some of the things which young engineers and young college graduates generally must take into account in planning what they will try to do with their lives. Any such attempts venture, of course, upon the dangerous field of prophecy. It seems clear, however, that at least one change is reasonably certain. The rule of the salesman is over.

"Young people who have grown up during the past 20 years probably have difficulty in imagining any large business in which the emphasis is placed upon anything else than salesmanship and advertising. It has been the star salesmen who got the star salaries. It has been the successful maker of slogans whose advice was sought and who got the major share of the profits. It is worth remembering, however, that this has not been so always.

"These major depressions may be regarded, in a quite real sense, as marking business generations. Business customs are born, become mature, and die just as the birth and death of individuals mark the generations of the public. The business generation between the seventies and the nineties was dominated by industrial development. Then it was the organizer and engineer whose advice was foremost and whose salaries were largest.

"The last business generation, which now is ending, was dominated by salesmanship. Production already had reached a large mark. Competition centered in getting rid of manufactured articles, not in producing them. The salesman had his innings; but, like all innings, they have come to an end.

"Another thing that seems reasonably certain is that the era of the great business also is passing. The advantages of a billion dollar organization are much more evident in sales, public prestige and similar matters, than they are in the actual conduct of the business itself. As salesmanship becomes less important the power of these advantages declines.

"Another disadvantage of the bigbusiness has become evident recently. This is the disadvantage of committee management. The size of a business which any one man can manage is strictly limited. If the business grows beyond this size, many men must be associated in the management. To meet this problem business has invented the device of executive committees, boards of directors, and the like. There are unquestionable advantages in this system, but one definite disadvantage in that initiative is stifled. Any one who has sat on committees of any kind is aware that the 'no-man' is more powerful than the 'yes-man.' If some one proposes a new and perhaps useful plan, this must run the gauntlet of opposition from every member of the board or committee. If any one opposes, the plan is dropped.

"We must not minimize the great advantage of this for certain purposes. It prevents mistakes. For a business which is well established and unchanging in an unchanging world, this method is ideal. That is why it usually works with some success in banking since banking is a business that changes little and tries, so far as it can, to ignore changes in other businesses. A major depression, however, usually sweeps away all businesses, even banks, which cannot adjust themselves to new conditions. The places of these casualties are taken, usually, by smaller businesses, directed by single individuals, able to make changes quickly, to move rapidly and to keep up with emergencies. It seems probable, therefore, that the successful businesses of the next business generation will be organized in smaller units directed by a single individual or, at most, by a small, cohesive group.

"As purely academic discussion of the business situation this has but little interest. The reason for devoting time to it is to see how this may affect the chances of college graduates in engineering to get jobs. On the whole, I think the outlook is hopeful, but in a different way from the way to which young graduate engineers have become accustomed during the business generation that has passed. The past method usually was to get a job with one of the large corporations. That now is impossible, and may remain impossible. The opportunities now, if I am right, are in small businesses. Such businesses need scientific and engineering help just as much as large businesses do, but they are unable to build up the expensive research departments to which we are accustomed. The necessary substitute is 1 or 2 young scientific men in each business reasonably well trained in engineering but also well

trained in the practical requirements of the business. This seems to me to be the great coming opportunity for young engineers.

"It is obvious that something in addition to engineering training is required. This something is business training. The prescription for young engineers out of jobs is, therefore, either college education in business or some actual business job where the operations of practical business policies may be observed and absorbed.

"Best of all, there seems at least a possibility that young engineers now entering business may have the best of all opportunities; the opportunity to build and own a business of their own. Small business men have had a hard time in life during the business generation that is passing. Many of them have vanished from the scene. My thesis is that this no longer will be true; that small business men now will have substantial advantages over large businesses, even in competing lines.

"The engineer trained in exactness, in fact-facing, in the need of obtaining full knowledge before making decisions, has what probably is the best training for the management of a business; provided he adds to it such elementary knowledge of business methods and systems as every successful business man must possess. There is no reason why the new crop of successful small business men which I foresee for the coming business generation should not be composed, in considerable degree, of young engineers."

Section and Branch Activities Summarized in Annual Report for 1932–33

IN PLACE OF the annual pamphlet report that previously has been prepared and distributed to a limited extent, the accompanying information summarizes comprehensively that important portion of Institute activities that falls under the jurisdiction of the Institute's committees on Sections and Student Branches. The period covered is the fiscal year ending April 30, 1933. Similar information for the fiscal year ending April 30, 1932, was presented in ELECTRICAL ENGINEERING for October 1932, p. 738–40.

The Sections committee of the Institute is composed of Everett S. Lee, *chairman;* W. B. Kouwenhoven, G. H. Quermann, J. J. Shoemaker, I. M. Stein, W. H. Timbie, and, ex-officio, the chairmen of all Sections of the Institute. The Institute's committee on Student Branches is composed of W. H. Timbie, *chairman;* W. E. Freeman, F. O. McMillan, C. F. Scott, W. J. Seeley, and, ex-officio, all Student Branch counselors.

Section Activities

During the fiscal year which ended April 30, 1933, the Sections maintained the normal extent and variety of their activities, retaining all the special features developed during recent years. Outstanding examples of these are: the increased participation of their own members in the programs, the 2 annual joint meetings of the Pittsfield and Schenectady Sections for the presentation of papers by younger members in competition for prizes, the 4 technical groups of the New York Section and the power group of the Chicago Section, educational activities, offering of prizes, and encouragement of cooperative relations with Branches.

Special efforts were made by many Sections to retain their members who had been seriously affected by the economic conditions, and much assistance was rendered to unemployed members.

In connection with the plan approved by the board of directors in 1932 for the appointment of a committee on transfers in each Section to encourage members who are qualified for the higher grades to submit their applications for transfer and for the appointment of a national standing committee on transfers to coordinate these efforts, many of the Sections appointed such committees which have been active in stimulating transfers.

Table I—Section Meetings Held During Last 3 Fiscal Years

	Fiscal Year Ending April 30		
	1931	1932	1933
Number of Sections	59	60	60
Number of meetings held	491	497	498
Average number of meetings	8.3	8.3	8.3
Total attendance	108,523	105,325	73,806
Average attendance per meeting	221	212	148

Detailed information on Section meetings during the past fiscal year is given in Table II, and Table I contains a brief summary covering meetings of the last 3 fiscal years.

Branch Activities

The Student Branches of the Institute continued their activities on a normal scale during the fiscal year which ended April 30, 1933, with the usual emphasis placed upon papers and talks by the Students, who presented a total of nearly 1,000, exclusive of a large number included in programs of Student conventions and joint meetings with Sections.

Events of the past year have added emphasis to the importance of the selection of Branch officers who have the qualifications necessary for the best performance of their varied duties, and there are definite indications that much progress in this direction has been made in recent years.

At its meeting on December 6, 1932, held instead of the regular December meeting of the board of directors, the executive committee authorized the organization of Student Branches at the George Washington University, Washington, D. C., and the University of Porto Rico, Mayaguez, Porto Rico. Both were organized promptly and

Table II—Section Meetings Held During Year Ending April 30, 1933

	A.I.E.E. Members		Meetings During Year		
Section	Aug. 1931	Aug. 1932	Number	Avg. Attendance	Avg. Attendance as Per Cent of Membership Aug. 1932
Akron	75	84	8	153	182
Atlanta	102	86	7	102	119
Baltimore	217	197	8	121	61
Birmingham	38	30	2	32	107
Boston	513	456	8	152	33
Chicago	1,098	850	7	190	22
Power Group			4	106	
Cincinnati	168	162	10	143	88
Cleveland	274	257	7	198	77
Columbus	62	73	7	135	185
Connecticut	263	254	8	108	42
Dallas	114	103	9	96	93
Denver	154	134	10	52	39
Detroit-Ann Arbor	310	268	10	193	72
Erie	99	65	9	85	131
Florida	42	48	2	37	77
Fort Wayne	80	71	7	81	114
Houston	71	56	9	76	136
Indianapolis-Laf	88	85	6	113	133
Iowa	62	58	3	62	107
Ithaca	38	42	3	109	259
Kansas City	158	165	9	179	109
Lehigh Valley	271	248	7	187	75
Los Angeles	477	413	9	154	37
Louisville	53	53	8	74	140
Lynn	134	122	10	398	326
Madison	55	60	6	59	98
Memphis	53	40	10	47	118
Mexico	94	74	11	39	53
Milwaukee	221	218	15	202	93
Minnesota	96	99	8	73	74
Montana	26	34	6	27	79
Nebraska	55	57	7	88	154
New York	3,794	3,394	3	783	23
Communication Group			2	400	
Illumination Group			4	438	
Power Group			4	469	
Transportation Group			3	308	
Niagara Frontier	176	162	12	98	60
North Carolina	83	80	2	124	155
Oklahoma City	64	77	10	98	127
Philadelphia	760	678	8	234	34
Pittsburgh	724	572	7	289	50
Pittsfield	137	117	11	661	565
Portland	121	88	11	68	77
Providence	80	80	8	50	62
Rochester	103	87	12	68	78
St. Louis	256	227	9	198	87
San Antonio	65	54	7	66	122
San Francisco	460	435	8	347	80
Saskatchewan	39	36	10	29	80
Schenectady	456	424	12	232	55
Seattle	218	181	5	58	32
Sharon	111	75	9	146	195
Southern Virginia	85	79	3	136	172
Spokane	46	39	8	67	172
Springfield, Mass	99	96	9	150	156
Syracuse	68	72	5	246	342
Toledo	87	83	19	71	85
Toronto	388	372	15	125	34
Urbana	36	38	5	194	510
Utah	58	53	7	41	77
Vancouver	91	85	7	39	46
Washington	183	181	7	106	58
Worcester	61	65	6	34	52
Total 60	14,410	12,892			

Total number of meetings 498
Total attendance 73,806

have been active. These brought the total number of Branches to 111.

The committee on Student Branches is studying methods by which the number of Students enrolling in the Institute may be increased.

Tables III to VII, inclusive, contain information on Branch activities during the past fiscal year.

Section and Branch Joint Meetings

The many Sections which have in recent years established cooperative relations of various types with neighboring Branches have maintained them and given much attention to methods of making them more beneficial to the students. During the past year, these cooperative activities have been appreciated by the students even more than in the preceding years.

Outstanding examples of such cooperation during the year which ended April 30, 1933,

Table III—Branch Meetings Held During Year Ending April 30, 1933

Branch	Meetings During Year: Number	Meetings During Year: Avg. Attendance	Approx. No. of Talks by Students
Akron, University of	3	9	3
Alabama Polytechnic Institute	10	25	2
Alabama, University of	14	53	14
Arizona, University of	16	9	8
Arkansas, University of	16	28	43
Armour Institute of Technology	12	44	
British Columbia, Univ. of	8	18	21
Brooklyn, Polytechnic Inst. of	8	45	13
Bucknell University	6	47	4
California Institute of Tech.	9	112	6
California, University of	23	158	10
Carnegie Institute of Tech.	9	56	9
Case School of Applied Science	4	67	2
Catholic University of America	3	16	2
Cincinnati, University of	1	80	
Clarkson College of Technology			
Clemson Agricultural College	14	35	37
Colorado State Agr. College	12	17	7
Colorado, University of	13	225	5
Cooper Union	3	38	
Cornell University	7	42	9
Denver, University of	12	30	1
Detroit, University of	4	37	
Drexel Institute	18	31	6
Duke University	12	39	11
Florida, University of	11	46	8
George Washington University*	5	22	2
Georgia School of Technology	9	51	
Harvard University	5	48	2
Idaho, University of	11	33	2
Illinois, University of	10	111	1
Iowa State College	11	50	9
Iowa, State University of	22	35	20
Kansas State College	15	69	20
Kansas, University of	9	55	19
Kentucky, University of	6	68	1
Lafayette College	9	42	9
Lehigh University	6	171	4
Lewis Institute	10	132	
Louisiana State University	3	22	
Louisville, University of	9	17	6
Maine, University of	2	25	
Marquette University	10	35	4
Massachusetts Inst. of Tech.	7	34	4
Mich. Col. of Mining and Tech.	9	40	3
Michigan State College	11	25	6
Michigan, University of	9	43	2
Milwaukee, School of Engg. of	8	81	3
Minnesota, University of	11	843	10
Mississippi State College	6	28	2
Missouri School of Mines and Met.	2	24	1
Missouri, University of	8	25	3
Montana State College	25	75	92
Nebraska, University of	11	71	5
Nevada, University of	4	21	1
Newark College of Engineering	10	29	6
New Hampshire, University of	26	28	44
New Mexico, University of	10	11	8
New York, Col. of the City of	15	44	1
New York University	11	20	29
North Carolina State College	12	45	14
North Carolina, University of	10	38	6
North Dakota Agr. College	5	28	1
North Dakota, University of	14	23	11
Northeastern University	1	40	
Notre Dame, University of	12	59	11
Ohio Northern University	11	29	7
Ohio State University	7	111	2
Ohio University	6	21	4
Oklahoma A. & M. College	16	32	9
Oklahoma, University of	6	34	2
Oregon State College	14	47	11
Pennsylvania State College	7	40	3
Pennsylvania, University of	2	19	
Pittsburgh, University of	24	95	25
Porto Rico, University of*	5	13	3
Pratt Institute	10	71	5
Princeton University	3	19	2
Purdue University	8	131	
Rensselaer Polytechnic Inst.	6	238	
Rhode Island State College	10	75	5
Rice Institute	3	15	
Rose Polytechnic Institute	12	35	10
Rutgers University	11	21	7
Santa Clara, University of	4	36	
South Carolina, University of	22	36	36
So. Dakota State School of Mines	6	28	
So. Dakota, University of	1	13	
Southern California, Univ. of	8	26	
Southern Methodist University	8	24	5
Stanford University	7	48	4
Stevens Institute of Tech.	1	44	
Swarthmore College	1	10	
Syracuse University	19	22	36
Tennessee, University of	10	19	10
Texas, A. & M. College of	9	84	7
Texas Technological College	7	20	6
Texas, University of	4	17	2
Utah, University of	8	45	2
Vermont, University of	13	14	15
Virginia Military Institute	12	77	45
Virginia Polytechnic Institute	24	42	57
Virginia, University of	5	27	5
Washington, State College of	10	23	
Washington University	9	49	2
Washington, University of	24	32	10
West Virginia University	9	24	62
Wisconsin, University of	5	37	3
Worcester Polytechnic Inst.	2	55	
Wyoming, University of			
Yale University			
Total	111		985
Total number of meetings	1,026		
Total attendance	59,439		

* Authorized by executive committee: December 6, 1932.

Table IV—Branch Meetings Held During Last 3 Fiscal Years

	Fiscal Year Ending April 30: 1931	1932	1933
Number of Branches	109	109	111
Number of meetings held	1,137	1,135	1,026
Average number of meetings	10.4	10.4	9.3
Total attendance	51,807	54,197	59,439
Average attendance per meeting	46	48	58
Number of student talks	1,085	1,066	982

Table V—Comparison of Branch Activities by Districts

District	No. of Branches Jan. 1	Avg. No. Meetings per Branch	Avg. Attendance per Meeting	Approx. Avg. No. Student Talks per Branch	No. of Branches Reporting 8 or More Student Talks
1	13	7.5	42.2	8.6	4
2	19	7.0	54.3	7.7	3
3	9	8.2	36.8	7.1	2
4	17	11.1	40.8	14.9	9
5	16	10.3	110	5.1	5
6	9	8.2	66.3	3.3	1
7	14	8.7	38.0	9.1	5
8	7	10.3	77.2	4.1	2
9	6	15.3	46.7	19.5	3
10	1	8	18.0	21	1

Table VI—Conferences on Student Activities

District	Location	Date
1	Providence, R. I. (North Eastern Dist. Mtg.)	5/6/32
7	Norman, Okla. (Univ. of Oklahoma)	10/21–22/32
4	Knoxville, Tenn. (Univ. of Tennessee)	12/1–3/32

Table VII—Student Conventions

Sponsored by District	Location	Date	No. of Student Papers
1	Providence, R. I. (North Eastern Dist. Mtg.)	5/6/32	6
8 & 9	Vancouver, B. C. Canada (Pacific Coast Conv.)	8/31/32	11
7	Norman, Okla. (Univ. of Oklahoma)	10/21–22/32	10
4	Knoxville, Tenn. (Univ. of Tennessee)	12/1–3/32	12
Phila. and Lehigh Valley Sections	Drexel Institute	3/13/33	4
3 (and New York Section)	New York	4/28/33	3

Table VIII—Section or Joint Section and Branch Meetings With Active Student Participation

Sections	Schools	Date	Student Talks	Attendance
Nebraska	Univ. of Neb.	11/14/32	3	102
Montana	Mont. State Col.	2/ 9/33	1	27
Iowa	Iowa State Col.	3/ 8/33		85
Los Angeles	Calif. Inst. of Tech. Univ. of So. Calif.	4/ 4/33	5	163
No. Carolina	Duke Univ.	4/ 7/33	1	110
Cleveland	Case School of App. Sci.	4/20/33	2	130

are given in Tables VIII and IX. In addition to the technical meetings listed, many joint dinner meetings and other activities of a fundamentally social character were sponsored by various Branches and Sections.

Table IX—Section or Joint Section and Student Meetings With Student Programs

Sections	Schools	Date	Student Talks	Attendance
Cincinnati	Univ. of Cinc.	5/12/'32	5	80
Oklahoma City	Univ. of Okla.			
	Okla. A. & M. Col.	5/16/'32	8	80
Portland	Ore. State Col.	5/21/32	4	125
Pittsburgh	Carnegie Inst. of Tech.			
	Univ. of Pittsburgh			
	West Va. Univ.	1/10/33	6	185
Dallas	So. Meth. Univ.	1/23/33	3	39
Madison	Univ. of Wis.	2/16/33	2	50
Minnesota	Univ. of Minn.	2/16/33	4	135
San Francisco	Univ. of Calif.			
	Univ. of Santa Clara			
	Stanford Univ.	4/13/'33	3	75
Providence	Brown Univ.*			
	Rhode Is. State Col.	4/25/33	6	65
Denver	Colo. School of Mines*			
	Colo. Agr. Col.			
	Univ. of Colo.			
	Univ. of Denver	4/28/33	4	50
Ind.-Laf.	Univ. of Ill.			
	Purdue Univ.			
	Rose Poly. Inst.	4/29/33	7	33

* No Branch.

Guggenheim Medal in Aeronautics Awarded

The Daniel Guggenheim Medal, recognizing "notable achievement in the development of aeronautics" has been awarded for 1933 to Commander Jerome Clarke Hunsaker, vice-president of the Goodyear-Zeppelin Corporation, Akron, Ohio. Commander Hunsaker was born in Creston, Iowa, in 1886, and graduated from the United States Naval Academy in 1908. He received the degrees of master of science and doctor of engineering from Massachusetts Institute of Technology, Cambridge. He introduced the application of aerodynamic research in the design of American aircraft, and designed the first modern nonrigid airship produced in the United States.

Presentation of the Guggenheim Medal for 1932 will be made to Juan de la Cierva as a feature of Engineers' Day at the Century of Progress Exposition in Chicago, Ill., June 28, 1933. The ceremony will take place at 10:30 a.m. in Soldiers' Field included within the Exposition grounds.

Booklet on the Valuation of Patents.—There has been prepared by G. H. Morse (F'22) a booklet entitled "The Valuation of Patents." Divided into 2 parts, this discusses first patent valuation, and second application of principles. General principles of the patent law and the relative desirability of different kinds of patents are discussed, and the methods whereby the value of a patent may be demonstrated are stated. Directions are given as how to proceed with a new invention. This booklet, 20 pages in length, can be obtained from the author, P. O. Box 271, Washington, D. C., at a cost of 25 cents postpaid.

Modern Connectors for Timber Construction

The national committee on wood utilization of the United States Department of Commerce, with the desire to improve existing wood-framing methods, made an extensive survey of wood-construction methods and joint details as practiced in European countries. Through this survey data were collected on 60 types of wood and metal connectors. While some of the types are of theoretical interest only, a large number of those investigated are important, and their use will promote more economical designs for wooden structures.

The purpose of the connectors is to improve the efficiency of the timber joint, which under systems of fastenings commonly employed was the weak point in timber construction, and made it practically impossible to develop the strength of many timber assemblies. Practical and economic means of securing relatively high efficiency in joint details has naturally given designers more latitude in the use of wood for many types of structures, and efficient systems of connectors by their ability to develop more nearly the member strength have made possible the use of smaller sizes of timber, and even of timber having lower mechanical properties than formerly considered advisable.

European engineers, although forced generally to use wood of lower strength properties than are common to the structural species of the United States, have built long-span structures in large numbers by the use of connectors. These structures, of almost every conceivable type, have been erected abroad, and new structures are constantly appearing. Among them are numerous radio towers, one of which is 460 ft in height, bridges of considerable span, and an auditorium with a seating capacity of 75,000 persons. Modern pier buildings, railroad stations, locomotive shops, warehouses, churches, and airplane hangars with a multiplicity of framing details furnish other examples of timber structures now being economically erected in Europe.

Modern connectors are essentially dowels developed to a high degree of efficiency. They consist of rings, plates, or discs which are embedded in the faces of members to be joined, and are held in place by a central bolt. Connectors are embedded in the surface of the wood and distribute the load over a much greater area, thus increasing materially the joint strength.

These structures built during the last decade have demonstrated the practicability of securing efficient joints. While their use in the past has been confined principally to European countries, these systems hold considerable promise for wider use in the United States after they become better known.

Of the many kinds of connectors available it appears that no one particular type is best under all conditions. Tests on the more promising types of connectors have been conducted at the United States Forest Products Laboratory. The results of these tests are published in a bulletin compiled jointly by the laboratory and the national committee on wood utilization of the United States Department of Commerce, entitled "Modern Connectors for Timber Construction." This bulletin is now available and may be obtained from the government printing office, Washington, D. C., for 15 cents.

This bulletin discusses generally types of framing which have been erected in Europe, gives the results of the research conducted at the Forest Products Laboratory, and presents authentic information and data necessary for the design of joints and the selection of connectors. The subcommittee sponsoring this report is under the chairmanship of Maj. H. S. Bennion (M'27).

Volume on Conduction of Electricity in Gases.—As one of a series of volumes intended for educational work carried on jointly by the graduate school of the University of Pittsburgh, Pa., and the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., "Conduction of Electricity in Gases" has been prepared. A small edition has been printed by the Westinghouse company primarily for the use of educators in other schools. The course is conducted by Dr. J. Slepian (A'17, F'27). The purpose of the course is to study the phenomena attending the passage of electricity through gases. In the first part, particular attention is paid to the fundamental principles, and in the rest, these fundamentals are used in the study of such discharges as glows, arcs, sparks, and corona, and their practical applications are indicated. Copies of this course can be obtained on application to the supervisor of extension courses, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. It consists of 180 diagrams and 188 pages photolithographically reproduced directly from typewritten copy, permanently bound in cloth, and costs $4.00 net.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely.

Balancing of Economic Forces

To the Editor:

I gladly accept your invitation to comment on the second progress report of American Engineering Council's committee on the relation of consumption, production, and distribution. Being deeply interested in the subject, I have been able to keep in quite close touch with Mr. Flanders and some other members of the committee, also with some others who have contributed their opinions, as published in the progress report. Many of my thoughts therefore go back considerably before the publishment of the report.

The members of the committee should assuredly be given great credit for their extensive study of this very complex subject and their report should contribute in no small degree to the crystallization of the thoughts of the hundreds who are also trying to contribute something worth while to the solution of this all important problem.

One thing that it seems to me would simplify the problem somewhat would be to group under one head, one large class of undesirables, namely, all income that may be described as "unearned incomes." It may be quite impossible to demonstrate that all unearned income contributes to business instability but I believe that if each of us could avoid selfishness sufficiently to advocate the elimination of all sources of unearned income we would not only be doing what is right ethically but would eliminate a great source of business unstability.

I am not one who would class reasonable profit on loans and investments as unearned wealth, for we must retain these as legitimate and necessary so long as we are to avoid socialism, but I do class as unearned and therefore undesirable, all income from the following sources:

1. Speculation, when not based on real and sound investments.
2. Profit from dishonest sales of useless or inflated securities.
3. Unearned increments in the value of land.

If these sources of income could be largely eliminated, I am confident that the problem of maintaining economic balance would be greatly simplified. I am quite inclined to agree with Mr. Wilgus when he says that the report does not sufficiently emphasize the harmful effect of betrayal of trust and similar dishonesty, on the markets collapse and, for this reason, would place great importance in the above second undesirable. If Mr. Winthrop W. Aldrich's proposed banking and investment reforms can be carried out betrayals of trust that Mr. Wilgus refers to should be immensely reduced.

As to public works being a major way to correct a drooping cycle, as proposed in my good friend J. C. Lennox's book, as well as by many others, I am sure that it has been already demonstrated that this can never be a major way to correct a serious depression when moving at full speed down hill. When started up hill again things can doubtless be accelerated somewhat by public works that we can ill afford at such times but which, in view of prompter recovery may not be out of the question. On this basis, it may not be too early for the President's program of public works.

I am disappointed that the report does not seriously consider the possibility of eliminating rather than reducing economic cycles. Professor Harwood's proposition to do this by government control of credit expansion may not be alone capable of doing this but it surely would help greatly, and coupled with Mr. Gerard Swope's proposition might function fully.

There is, of course, a large group among our wealthy, who have no desire to see such cycles disappear, because they think that they give them fine opportunity for skillful money making by the unearned route, but if the reforms that Mr. Aldrich proposes for banking and investment can be brought about the days of those who can thus profit at the expense of the Public should be largely over.

Very truly yours,
WALTER S. MOODY (F'12)
(Consulting Electrical Engineer, 155 Dawes Ave., Pittsfield, Mass.)

Graphical Determination of Symmetrical Components

To the Editor:

In his "Letter to the Editor" published in ELECTRICAL ENGINEERING for April 1933, p. 280, J. B. Troja notes 2 errors which he found in my previous letter on the "Graphical Determination of the Symmetrical Components in a 3-Phase Unbalanced System" in the December 1932 issue, p. 886–7.

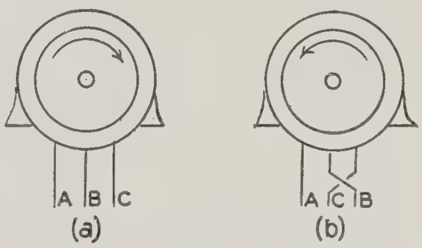


Fig. 1

As a matter of fact, the 2 things to which he objects may not be according to the ordinary conventions but I do not think there is any actual error in them.

A clockwise revolution of 3 balanced vectors *ABC* represents the same physical phenomenon as the counterclockwise revolution of 3 vectors *ACB*. In other words, if we suppose a 3-phase generator, we obtain the same result whether we reverse the rotation (Fig. 1*a*) or twist 2 of the outcoming wires (Fig. 1*b*). The negative sequence is just an analytical method of representing a reverse rotation.

Mr. Troja also finds a contradiction in the Fig. 6 of my letter where the positive phase sequence is called *ACB;* I do not suppose a phase sequence is positive because it is called *ABC* or *ACB* but because it is the same sequence as in the original 3-phase system. If by convention the 3-phase system is called *ACB*, then the positive sequence is *ACB*. In my Fig. 6, I changed the position of the letters on purpose, in order to apply the graphical method to an altogether different example.

Very truly yours,
RENÉ LAPLANTE (A'32)
(Shawinigan Water & Power Co., Shawinigan Falls, Quebec, Can.)

More Is Needed Than "Balancing of Economic Forces"

To the Editor:

During the past several months I have watched with interest the several articles and letters pertaining to the depression which have appeared in ELECTRICAL ENGINEERING. I would like to take this opportunity to set forth some economic principles which the study of these articles has called to my attention.

Even in an engineering analysis such as a study of the causes of the present depression it is necessary to make some preliminary assumptions in order to establish a working hypothesis. However, for the present let us review the economic history of the past 2 decades. In 1913 the price trends of stocks and commodities were taking what appeared to be a steady upward turn, indicating an ensuing period of moderate but "true" prosperity. The declaration of war in Europe caused an immediate inflation of prices in foreign markets with its resulting stimulation of world markets and a corresponding inflation of American business. However, these trends clearly indicate that not until the United States entered the war did this inflation reach a point where it was out of control. . . .

A well established law of nature states that for every action there is a corresponding, equal, and opposite reaction. So it is with the economic cycle. As a result the latter months of 1919 and during 1920 this country was faced with a rapid deflation of credit and prices and such a deflation is always accompanied by a depression. However, much to our present regrets, the reaction was not equal to its corresponding and opposite action. . . . The reason the depression of 1920 did not continue was because, due to the fact that we entered the war after the countries of Europe were well exhausted by their efforts, we were fortunate to come out comparatively unscathed and with our great resources well intact. Naturally, with Europe extremely weak we were competing alone in world markets. Whenever such a monopoly occurs in any market the result is usually disastrous unless the monopoly is conscientiously controlled. Apparently it was not. This condition of monopoly apparently increased in magnitude until an expansion of business began which immediately absorbed our accumulated capital. As is true in all

previous economic cycles this expansion of industry came too late in the cycle. It was uncontrolled. A rapid inflation occurred. Then our natural laws of reactions asserted themselves again and we were confronted with a deflation whose magnitude must obviously satisfy both the present conditions and the one which was arrested 10 years before. These were the conditions which faced the world in 1929. At that time due to inexperience of the men who were in control they were not clearly recognized. Undoubtedly the efforts of these men have contributed to the depth of our present position. It is evident that men who had come into industry and finance after 1910 had had little experience with such conditions. It is easily conceivable that their efforts to harness the monster, deflation, may have been misdirected. Such appears to be the case. . . .

Although several pages have been written concerning the many forces which were out of control in 1928 and 1929 the literature appears misdirected. The inevitable postwar deflation which I have attempted to justify as the fundamental cause has been left practically untreated in proportion to its magnitude. For example, if we assume that the World War had never occurred, is it not reasonable to suppose that the past 2 decades would have seen several minor inflations and deflations accompanying a general upward trend in industry which was advancing by a slow expansion made possible by increasing research? . . . .

I have tried to justify the omission of this obstacle (war) from other's reasoning on the subject. Is it that writers believe the balancing of less fundamental economic forces will eliminate this gigantic and more fundamental one? It is apparent that such a train of reasoning is isolated from the truth.

From the above trend of thought I have drawn the following conclusions in regard to our present condition and in connection with some thoughts concerning the proposed methods of eliminating a reoccurrence of future depressions. These conclusions are:

1. The elimination of the repeated occurrence of wars, and that as long as war clouds continually hover in the world we can never hope for a "depressionless" future.

2. That the magnitude of our present condition has been aggravated by the inability of the men in control to cope with the situation due to their lack of experience with any previous similar situation.

These conclusions appear to me to be self-evident. They are fundamental in nature. Their elimination entails a gigantic reconstruction program. A reconstruction program, not of consumption, production, and distribution but of education and brotherly love. Surely the problem is far greater and more far reaching than a mere balancing on the American continent of consumption, production, and distribution. Unquestionably this is not a problem for the engineer nor any other group of men. It is a problem to be solved in every home, in every land by everybody. With its solution will follow the solutions of our less fundamental problems of economics. Emerson says that the day was when a man looked out that his neighbor did not cheat him but the day will come when a man looks out that he does not cheat his neighbor. That day must come. Until it does we cannot hope to eliminate depressions and we must always realize that a degrading component of forces exists in our social and economic systems which impedes and may eventually destroy the advance of civilization.

Very truly yours,
WM. HAMILTON TREADWAY
(Enrolled Student)
(Milwaukee School of Engineering, Milwaukee, Wis.)

Engineers Versus Business Men and Politicians

To the Editor:

Is it not about time that the scientist and the engineer, both, balked at the position in which our "safe and sane" business men and our politicians seek to put them?

In "II—Private Enterprise" by Virgil Jordan on p. 236–7 of ELECTRICAL ENGINEERING for April 1933, Mr. Jordan assigns to Veblen the statement that "engineers are a somewhat fantastic brotherhood of over-specialized cranks . . . . ." Evidently Mr. Jordan lacks the usual Hibernian sense of humor, else he would not have construed his Veblen thus.

Among other recent things of the same sort, there appeared in the *New York Times* a column ostensibly discussing the presentation of the Nobel prize to Langmuir, but chiefly devoted to a criticism of the scientist, including the medical man, and the engineer, for their lack of purpose evidenced by the fact that they render service to their fellowmen independently of the political and economic boundaries so carefully set up by our "safe and sane" business men and politicians together, and independently of the antagonisms aroused by such boundaries. This I call a highly complimentary criticism. I am proud that I belong to a "fantastic brotherhood" that has proved the workability of a certain Christian doctrine to the general benefit of mankind short of the use made of scientific knowledge by "safe and sane" business men and by politicians to their own assumed advantage.

In this column, also occurs the statement that only the politician knows how to run things. I leave it to your readers to realize how excellent a job the politician has made of it. So, too, in Mr. Jordan's paper appears a continuation of the above "quotation" from Veblen that "the engineer is not to be trusted out of sight except under the restraining hand of the safe and sane business man." I ask your readers to observe what "the restraining hand of the safe and sane business man" has produced in the form of a stable and smoothly functioning economy.

Mr. Jordan's article has that defect common to most recent discussions by economists, politicians, and business men, of our economic situation. Such are drawn from independent orders of facts—a sort of conglomerate of presuppositions, independent, not because they are logically independent within the same order or class of facts, but because they are not related at all. Such seem to be mere items of belief.

You will note that Mr. Jordan closes with the remark, "I prefer to believe . . . . ." Truly, what one prefers to believe is a solid foundation for the analysis of the performance of our system for the production, distribution, and use of physical goods. Imagine an engineer expressing his "preference" as to the operating characteristics of an induction motor—that he "preferred to believe" that its characteristics were the same as a d-c series motor—or that he "preferred to believe" that the cause of trouble in the operation of the motor was due to this rather than that!

Thus, Mr. Jordan prefers to believe that the failure of big business enterprises under independent control implies the wisdom of creating a multiplicity of small individual business enterprises under a complete dispersion of control, which, of course, would involve the scrapping of the entire existing machinery of production. This is almost an example of prelogical thinking. He presents no underlying reason for the failure of such larger enterprises. That apparently they have failed is sufficient reason for his preferences as to the cause of such failure. This is indeed an application with a vengeance of the principle of sufficient reason. It is an example of that sort of reasoning based upon the emotion of fear that leads to the hurried and perhaps even more dangerous abandonment of a leaking ship in a storm without first investigating the leak and taking all necessary measures to stop it.

Mr. Jordan implies, although he does not say so outright, that Professor Rautenstrauch's paper which also appears in your April 1933, issue, p. 234–6, suggests that "public enterprise" be substituted for "private enterprise," for which implication I cannot find the least evidence, even though the 2 papers are grouped under such a heading. I wonder, Mr. Editor, if you read both papers carefully. [ED. NOTE: Editor not only read both papers with care; he listened to both authors as they made their original presentations before the Advertising Club of N. Y.]

Professor Rautenstrauch points out very clearly that since the big enterprises, as Mr. Jordan also says, have not been stimulated by the incentive of profit to cooperate in devising a proper common system of control, and, as Mr. Jordan adds, therefore they have failed, it seems well to consider whether, and by what means, such a system of control may be devised and applied, if necessary even by others, in order that the production and distribution of those goods required for our living may be maintained irrespective of any rights to interfere with the process assumed by safe and sane business men and by politicians.

The only alternate to the hypothetical public control, suggested by himself, Mr. Jordan has to propose is scrapping the system and returning to the superseded era of what he calls "individual enterprise"—that in effect, every man should again become his own shoemaker—"digging in for self-sufficiency and increased independence." This is an excellent example of *a priori* reasoning based upon presuppositions. The output of such thinking is drawn from sanctions of expediency, from compromise with a situation rather than on orderly analytic precedure. So Mr. Jordan suggests a return to the age of individual economic struggle; to the period when 12 to 18 hours of hard labor a day was not always sufficient to keep the wolf from the door. If that represents liberty and the spirit of America, as Mr. Jordan prefers to believe it does, then let us save ourselves from it!

Mr. Jordan preaches a philosophy of defeat and despair. He seems to admit that the economic change of the past century represents effort wasted in traveling the wrong path. I think this merely proves that Mr. Jordan does not know the nature of the trouble and is quite hopeless about it. Just because a large power system shows signs of increasing instability with increasing load, does the engineer give up the job and advocate a return to the small independent plant? He does not! He finds the reason for the instability. Then he designs and applies the required system of control. Thus he proves himself to be a "fantastic, over-specialized crank."

After all, science and engineering both are attitudes of mind—ways of thinking about facts—; might it not be well if our business men and politicians both displayed some of the same sort of common sense, putting aside preferences for, and beliefs in, this or that economic or political creed, and, like the scientist, the microbe hunter, and the engineer, unafraid, look the facts straight in the face?

Strangely enough, Mr. Jordan states that "the industries of this country have never so far formed or supported any

comprehensive strong national organization even in order to advance their own interests. Though they need it today more than ever, and their very existence may depend on it, it has so far been impossible for even the leading executive industrialists of this country to develop any constructive plans to deal with the economic situation and act together to put them into effect." It is interesting to know what Mr. Jordan thinks of our leading industrial executives.

Is it not possibly correct that the so-called business man and his cohort the politician, have seemed "safe and sane" merely because during a certain phase of our industrial development, unknown to them, the game was so set that, on the whole, they could not lose their entire stake, and now that the luck has changed because the game has entered a new phase, none of their accustomed tricks will win, and they do not know what to do about it? Yet when the engineer, who built the plant, and is trained to study the nature of a game before he "sits in," rises up and points out what he thinks is the trouble, he is backhandedly accused by Mr. Jordan of being a "fantastic over-specialized crank!"

Since neither the pilot nor the captain of our ship seem to know what to do in these strange waters, and meanwhile she drifts nearer and nearer the shoals, it may be necessary as a last emergency measure to call someone else to the bridge. Once, when off course in a thick storm, the cook took the wheel and brought us safely through a channel he said he knew. While it was not the best place in the world to be, at least the coast guard did not have to rescue us from drowning.

Very truly yours,
BASSETT JONES (F'30)
(101 Park Avenue,
New York, N. Y.)

To the Editor:

In his article on "II—Private Enterprise" in the April issue, Virgil Jordan implies that Veblen called the engineers "a somewhat fantastic brotherhood of over-specialized cranks, not to be trusted out of sight except under the restraining hand of safe and sane business men."

Veblen did nothing of the kind. In his 1919 essay on "A Soviet of Technicians," enumerating the obstacles to the operation of industry by engineers in place of business men, he wrote: " . . . popular sentiment in this country will not tolerate the assumption of responsibility by the technicians, *who are in the popular apprehension conceived to be* a somewhat fantastic brotherhood of over-specialized cranks, not to be trusted out of sight except under the restraining hand of safe and sane business men." (Italics mine.)

Veblen's whole paper was an argument for technological direction of industry, although he saw no early prospect of such a revolutionary overturn, with the commercial spirit still dominating all classes. Mr. Jordan, by omitting the first part of the sentence, has misquoted Veblen and reversed the sense of the latter's argument, a rhetorical dodge which is of a piece with the rest of Jordan's special pleading for private profit. Engineers would do well to study "The Engineers and the Price System," which includes the above essay, instead of relying on distorted transcriptions of what Veblen thought and said.

Very truly yours,
CARL DREHER (A'23)
(RKO Studios, Inc.,
Los Angeles, Calif.)

Standards

Protective Relays

At the April 26, 1933, meeting of the Institute's standards committee, the A.I.E.E. report on "Standards for Relays," Nr. 23, which has been available in pamphlet form since August 1931 was recommended to the board of directors for transmission to the electrical standards committee. This report was developed by a subcommittee of the standards committee working under the chairmanship of George Sutherland, of the New York and Queen Electric Light and Power Company. Before passing the report on to the electrical standards committee it will be necessary to eliminate certain differences in the wording of definitions which are in Nr. 23, as well as in the general "Report on Electrical Definitions," Nr. 2. This latter report is in process of development under the sponsorship of the Institute.

Electrical Recording Instruments

E. J. Rutan, chairman of the Institute's instruments and measurements committee presented at the standards committee meeting of April 26, 1933, a "Report on Standards for Electrical Recording Instruments." This report has been in course of development for some time under the auspices of the instruments and measurements committee. The standards committee voted that the report be accepted and published in pamphlet form for criticism and suggestion. This work of publication will get under way at once and the report will probably be available early in June.

Indicating Instruments

Advice that the instruments and measurements committee was preparing a report on a proposed "Standard for Indicating Instruments" was presented to the standards committee at its meeting of April 26, 1933. Just when this will become available is not known at the present time.

Illumination Nomenclature and Photometric Standards

By action of the Institute's board of directors at their meeting of May 22, 1933, A.I.E.E. Standard Nr. 37, "Illuminating Engineering Nomenclature and Photometric Standards" was canceled. This standard which was developed by the Illuminating Engineering Society and approved by the Institute in 1925, has been replaced by a revised standard developed under the same auspices and approved as an American standard by the American Standards Association on December 19, 1932. Copies of the new standard may be obtained through the headquarters of the Illuminating Engineering Society, 29 West 39th St., New York, N. Y.

Vacuum Tube Standards Proposed

At the meeting of the Institute's standards committee held on April 26, 1933, a suggestion was received that standardization work should be undertaken in the vacuum tube field. It was pointed out that standardization of ratings, dimensions of tubes, and interchangeability would be of considerable advantage. The standards committee therefore recommended that the proposal be forwarded to the American Standards Association and that a sectional committee be formed to undertake the work.

New British Standards Received

For the information of members interested in foreign standardization the secretary of the A.I.E.E. standards committee advises that there has recently been received copies of 9 new or revised British standards. These are as follows: Nr. 52, bayonet lamp caps and metal-cased bayonet lampholders; Nr. 109, air break knife switches and laminated brush switches for voltages not exceeding 660; Nr. 124, totally enclosed air break switches for voltages not exceeding 660; Nr. 156, enameled high-conductivity annealed copper wire; Nr. 159, busbars and busbar connections; Nr. 367, performance of ceiling-type electric fans; Nr. 376, railway signaling symbols; Nr. 475, tractive armature d-c neutral line relays; Nr. 480, metal-sheathed paper-insulated plain annealed copper conductors for electricity supply. Copies of these and other British standards may be obtained by addressing the British Standards Institution, 28 Victoria Street, London, S.W.I., England. Loan of copies can probably also be arranged by writing the American Standards Association, 29 West 39th St., New York, N. Y., where a file of foreign standards is maintained for that purpose.

American Standards Yearbook for 1932–33

A new edition of the "American Standards Year Book for 1932–33" has just been issued by the American Standards Association. Among other things of interest to those in standardization work, this book contains a complete listing of all the projects that have an official status before the association now. It also contains an article

on how American standards are developed which may be of considerable help to those proposing new standarization undertakings and unfamiliar with proper procedure. Copies of the year book may be obtained by addressing the American Standards Association, 29 West 39th St., New York, N. Y.

Personal Items

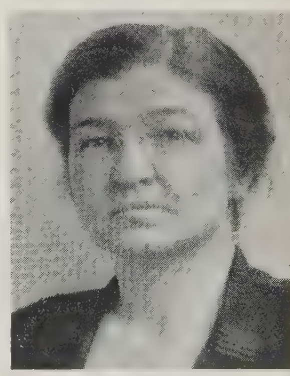
C. H. Sharp (A'02, M'12, F'12) vice-president and technical adviser, Electrical Testing Laboratories, New York, N. Y., has retired from the company's service and will engage in consulting engineering. Doctor Sharp received the degree of Bachelor of Arts from Hamilton College, Clinton, N. Y., in 1890, and the degree of doctor of philosophy from Cornell University, Ithaca, N. Y., in 1895, having specialized in physics. He spent 2 semesters at the University of Leipzig, Germany, in 1899 and 1900. Between 1895 and 1901 he was assistant and instructor in physics at Cornell University. Doctor Sharp entered the employ of the Electrical Testing Laboratories in 1901 as test officer at a time when this company's activities were confined to testing incandescent electric lamps; he has been actively identified with the company continuously since that time. His professional engineering work in the early part of the period consisted chiefly in the equipment of the laboratories, laying out methods of work, in general responsible charge of operation. Since 1914 he has been technical director in responsible charge of all the work carried on at the laboratories. The list of engineering testing operations carried on is a very long one and includes nearly all branches of electrical engineering, as for example, high voltage tests of insulators and insulating materials, tests of cables and other conductors, lamps, both arc and incandescent, investigations of electrolytic conditions in underground structures, maintenance of electrical and photometric standards, investigations and tests of measuring instruments, testing of electrical plants, etc. Recently he has devoted much attention to photoelectric methods as applied to photometry and spectrophotometry. Years ago he, with Preston S. Millar (A'03, M'13) developed the Sharp-Millar photometer which was the pioneer portable photometer in this country. Later he designed the well-known foot-candle meter. Doctor Sharp is the author of many technical papers, chiefly on electrical measurements and photometry, several of which have been presented before the Institute. He also has served the Institute for many years, having been a member of the board of examiners 1917–21, and the following committees: electrophysics 1916–17, instruments and measurements 1917–21, lighting and illumination (now production and application of light) 1914–19, meetings and papers (now technical program) 1914–16, standards 1916–19 and 1924–33, and research 1921–29. He is a representative of the Institute on the joint committee on the Edison memorial 1932–33. He has been a representative of the Institute on the U.S. national committee of the International Commission on Illumination continuously since 1914, and on the U.S. national committee of the International Electrotechnical Commission during the same period; he is a vice-president of the I. C. I., and between 1926 and 1932 was president of the U.S. national committee of the I. E. C. He also has been active in other technical organizations, being a fellow of the American Physical Society and the American Association for the Advancement of Science, a member of the American Optical Society, the Illuminating Engineering Society (past-president), the Société Française des Electriciens, Associzaione Elettrotechnica Italiana, and Verband Deutscher Elektrotechniker. He is a member of Alpha Delta Phi Fraternity, the Engineers' Club of New York, N. Y., and the University Club of White Plains, N. Y.

C. H. SHARP

A. G. Davis (A'98, M'00, F'12) vice-president of the General Electric Company, Schenectady, N. Y., in charge of patents, has recently entered the law firm of Pennie, Davis, Marvin and Edmonds, New York, N. Y. This firm, which specializes in patent work, already includes his younger brother, W. H. Davis. A. G. Davis graduated from Massachusetts Institute of Technology, Cambridge, in 1893, in electrical engineering. He then spent one year in Kentucky and Alabama in charge of the design and construction of Davis-Colby ore roasting furnaces, and in 1894 entered the United States patent office as an assistant examiner. In 1896 he resigned from the patent office and practiced patent law in Washington for one year. During this period he graduated from the National University Law School with the degree of bachelor of laws; and took a post graduate course, receiving the degree of master of laws. In 1897 he was placed in charge of the patent department of the General Electric Company at Schenectady, N. Y. It was in 1919 that he became vice-president of the company; he is a director of several corporations affiliated with the General Electric Company. He is a member of the American Bar Association, the American Patent Law Association, New York State Bar Association, and New York Patent Law Association. He is a member of several clubs in Schenectady and New York

W. S. Bachman (Enrolled Student) has, with his co-author, E. M. Wolf (Enrolled Student) received the 1932 A.I.E.E. North Eastern District prize for Branch paper for their work entitled "The Development of a Practical Television Receiver." This award was made jointly with another paper by D. W. Mack (Enrolled Student). Mr. Bachman, who was born in 1908 and whose home was Rising Sun, Md., graduated from Cornell University, Ithaca, N. Y., in 1932, receiving the degree of electrical engineer, having specialized in communication. During summer vacations he engaged in clerical work for the Diamond State Telephone Company, and did other telephone plant work. While in college, he engaged in many extra-curricula activities including intramural athletics, and the university orchestra, of which he served as president one year. He was a member of Eta Kappa Nu, Delta Club, and Kappa Delta Rho, and was secretary-treasurer of the local Branch of the Institute. Mr. Bachman is now employed in engineering work with a firm in Wilmington, Del.

Edith Clarke (A'23) central station engineering department, General Electric Company, Schenectady, N. Y., has received the 1932 A.I.E.E. North Eastern District prize for best paper for her paper entitled "3-Phase Multiple Conductor Circuits." Miss Clarke, a native of Maryland, attended Vassar College, graduating in 1908 with the degree of bachelor of arts. After graduation, she taught for 3 years and then spent a year at the University of Wisconsin



EDITH CLARKE

studying civil engineering. Between 1912 and 1915 she was assistant to the research engineer of the American Telephone and Telegraph Company, New York, N. Y., and between 1915 and 1918 was in charge of calculations (transmission) for the company. She then took graduate work at Massachu-

setts Institute of Technology, Cambridge, receiving the degree of master of science in electrical engineering in 1919. Following this she spent 2 years in the turbine engineering department of the General Electric Company, Schenectady, N. Y., in charge of calculations, and in 1922 became engineer in the lighting engineering department of the company. Shortly afterward she went to Turkey as professor of physics in Constantinople Women's College, and then returned to Schenectady, entering the central station engineering department of the General Electric Company where she has since remained.

H. L. Rorden (A'30) of Petaluma, Calif., and formerly research engineer for the General Electric Company, Pittsfield, Mass., has received honorable mention in connection with the 1932 A.I.E.E. North Eastern District prize for best paper. Mr. Rorden's paper was "The Solution of Circuits Subjected to Traveling Waves." He was born in The Dalles, Ore., in 1900, and received his technical education first from Heald's School of Engineering, San Francisco, Calif., and later from Leland Stanford Jr. University, Calif., receiving from the latter institution the degree of bachelor of arts in 1925, and the degree of electrical engineer in 1926. In 1925 and 1926, he was instructor in applied mathematics at Leland Stanford Jr. University, and from 1926 to 1928 was on the student test course of the General Electric Company. In the latter year he became research assistant in high voltage engineering for the company.

S. B. Crary, Jr., (A'31) who, with his co-author M. L. Waring (A'29) was awarded the 1932 A.I.E.E. North Eastern District prize for initial paper for their work entitled "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances" is a member of the central station engineering department of the General Electric Company, Schenectady, N. Y. Mr. Crary is a native of Michigan, and graduated from Michigan State College with the degree of B.S. in E.E. in 1927. In

S. B. CRARY, JR.

1932 Union College conferred upon him the degree of M.S. Following graduation in 1927 he joined the General Electric test course at Schenectady, and a year later was transferred to the transformer engineering department of the company at Fort Wayne, Ind. Late in 1929 he returned to Schenectady, and since that time has been in the central station engineering department.

M. L. Waring (A'29) who, with his co-author S. B. Crary, Jr. (A'31) has been awarded the 1932 A.I.E.E. North Eastern District prize for initial paper for their work entitled "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances" is associated with Chase and Waring, consulting engineers, New York, N. Y. Mr. Waring graduated from Virginia Military Institute in 1927

M. L. WARING

with the degree of B.S. in E.E. In 1932 he also received the degree of M.S. from Union College. For one year following graduation he was on the General Electric test course in Schenectady, N. Y., and was then in the d-c engineering department of the company for one year, and was then in the central station engineering department of the company until joining the staff of Chase and Waring.

E. M. Wolf (Enrolled Student) has, with his co-author, W. S. Bachman (Enrolled Student) received the 1932 A.I.E.E North Eastern District prize for Branch paper for their work entitled "The Development of a Practical Television Receiver." The award was made jointly with another paper by D. W. Mack (Enrolled Student). Mr. Wolf was born in 1910, his home having been in Bellevue, Ohio. He graduated from Cornell University in 1932, receiving the degree of electrical engineer. While a student he was on the varsity wrestling squad, and was a member of the Delta Club. Two of his summer vacations were spent as oiler on board steamships of the American Export Lines, and he is now electrician on the S.S. "Exeter" of the American Export Lines, plying between New York and South America.

D. W. Mack (Enrolled Student) has received the 1932 A.I.E.E. North Eastern District prize for Branch paper for his work entitled "A Superheterodyne for Long Distance Television Reception." The award was made jointly with another paper by W. S. Bachman (Enrolled Student) and E. M. Wolf (Enrolled Student). Mr. Mack was born in Ascutney, Vt., in 1910, graduating from the University of New Hampshire in 1932 with the degree of B.S. in E.E. In 1932 he did development work and prepared his thesis on television. During a summer vacation he was estimator for H. E. Noyes, engineer and builder, Claremont, N. H., and is now with the Signal Corps, U.S. Army, working on high frequency transmitters. He has operated amateur radio station WISC, 5–80–160 meters.

L. R. Nash (A'03, M'16) rate expert, Stone and Webster Engineering Corporation, Boston, Mass., has been appointed head of valuation and appraisal work for properties managed by and clients of the Stone and Webster Engineering Corporation, with headquarters in New York, N. Y. All rate research activities of Stone and Webster will continue under his direction. Mr. Nash recently was made a vice-president of the Stone and Webster Engineering Corporation, taking over the duties of the late W. H. Blood, Jr. (A'05, M'06, F'13). He has lectured extensively at Harvard University and the Massachusetts Institute of Technology, and is the author of numerous publications in the field of utility economics.

H. B. Gear (A'01, F'20) assistant to the vice-president, Commonwealth Edison Company, Chicago, Ill., and in charge of operating, construction, and electrical departments, was recently elected president of the Western Society of Engineers for the coming year. He has been a member of the society for 26 years. In 1910 the Western Society of Engineers awarded him the Chanute Medal for a paper on "Diversity Factor in the Distribution of Electric Light and Power."

L. C. Williams (A'15, M'26) for 8 years district manager of the Los Angeles, Calif., office of the Pacific Electric Manufacturing Company until illness in the early part of 1932 forced him to terminate this connection, has become a partner in the Coast Engineering and Equipment Company, Los Angeles. Fully recovered, Mr. Williams will participate actively in the work of the firm, which acts as manufacturers' representative in the industrial, heavy construction, and building specialties field.

W. J. Gilson (A'20, M'28) general superintendent of power and construction for the New York Power and Light Corporation, Albany, N. Y., since the organization of this company in 1927, has been elected a vice-president. He has supervised the company's extensive power expansion program during the past few years, including the building of the 145-mile 110,000/-132,000-volt line connecting the Niagara Hudson and the New York Edison systems.

J. W. Upp (A'03, M'12) manager of the switch gear sales department of the General Electric Company, Philadelphia, Pa., retired from service May 1, 1933, after 32 years of service with the company, including 26 years as manager of the department. Mr. Upp will continue in an advisory and

consulting capacity to the switchgear division of the central station department (formerly the switchgear sales department) and as a consultant for other departments of the company.

N. T. Wilcox (A'95, F'12, and Member for Life) who for 28 years was in various operating and commercial positions with Stone and Webster Engineering Corporation, Boston, Mass., and more recently New England representative of Hynes & Cox, Albany, N. Y., has recently established practice as a consultant in electrical sales development with headquarters at Melvin Village, N. H. He is a past chairman of the commercial national section of the National Electric Light Association.

C. E. Tullar (A'22, M'31) manager of the patent department of the General Electric Company, Schenectady, N. Y., has been appointed a member of the advisory committee and of the engineering council of the General Electric Company, succeeding A. G. Davis (A'98, M'00, F'12) who recently retired from these offices and as vice-president in charge of patents for the company.

E. E. Ashley, Jr. (A'11, M'13) electrical and mechanical engineer, Starrett and Van Vleck, New York, N. Y., has opened a private practice in New York, N. Y., for the general practice of electrical, mechanical, and sanitary engineering, including Diesel and power plant equipment and modernization, air conditioning, and elevators.

W. F. Grimes (A'19, M'27) formerly control engineer for the Westinghouse Electric and Manufacturing Company, Los Angeles, Calif., has accepted a position with Radio and Music Trades Association of Southern California. His new duties will include the supervision of the radio interference department.

E. M. Burckett (A'26) since 1929 electrical engineer in the engineering department of the Boston and Maine Railroad, Boston, Mass., has recently acquired increased responsibility, having been assigned to the duties of the late L. C. Winship, electrical engineer for the railway.

P. A. Westburg (A'07, M'16) manager, Chicago district, Weston Electrical Instrument Corporation, Chicago, Ill., was named treasurer of the Western Society of Engineers at its annual election held recently.

J. A. McHugh (A'22, M'28) assistant engineer, electrical engineering department, New York Edison Company, New York, N. Y., has been elected chairman of the power group of the Institute's New York Section for the year 1933–34.

W. H. Capen (M'23) assistant vice-president, International Telephone and Telegraph Corporation, New York, N. Y., has been elected chairman of the communication group of the Institute's New York Section for the year 1933–34.

C. A. Terry (A'87, M'87, and Member for Life) honorary vice-president of the Westinghouse Electric and Manufacturing Company, New York, N. Y., has been elected a director of the company for a term of 4 years.

L. R. Mapes (M'29) chief engineer, Illinois Bell Telephone Company, Chicago, Ill., was named trustee of the Western Society of Engineers at its recent annual election.

J. S. Hagan (A'20, M'31) electrical engineer, Central Railroad of New Jersey, Jersey City, has been elected chairman of the transportation group of the Institute's New York Section for the year 1933–34.

J. T. Holmes (M'24) engineer, The Frink Corporation, Long Island City, N. Y., has been elected chairman of the illumination group of the Institute's New York Section for the year 1933–34.

A. H. Kehoe (A'12, F'25) vice-president of the New York Edison Company, New York, N. Y., has been elected a member of the nominating committee for 1934 of the National Fire Protection Association.

Obituary

Clarence Everett Doolittle (A'95, M'10, F'13 and Member for Life) consulting hydroelectric engineer, retired, Glendale, Calif., died April 29, 1933. He was born in Mount Pleasant, Iowa, in 1863, received his early schooling in Washington, D. C., and graduated with honors from Cornell University in electrical engineering in 1885. He was a member of the Zeta Psi fraternity. After graduation he was connected with the Brush Electric Company, Cleveland, Ohio, for about one year, going to Aspen, Colorado, in August 1886, as electrical engineer for The Aspen Electric Company which had in 1885 installed a 60-light Brush arc dynamo belted to a Pelton wheel under 70 ft head. On the consolidation of The Aspen Electric Company with the Consumer's Electric Light and Power Company in 1887, Mr. Doolittle became the electrical engineer for the new company named The Roaring Fork Electric Light and Power Company which in the spring of 1887 installed 2 40-kw generators for incandescent lighting thus making Aspen the first town in America to have its dwelling houses as well as its streets and business houses lighted by electricity from water power. In 1887 with Frank J. Sprague and J. H. Devereaux, a mining engineer, Mr. Doolittle conceived the first electric hoist for mine use which consisted of a Sprague street car motor geared to an intermediate shaft connected to the hoist drum through a flat friction drive. This hoist was installed in the Veteran Tunnel, 1,000 ft under ground and was started in July 1887. Additional hoists were soon added until the existing plants were fully loaded so during the winter of 1888–89 the electric company built a new 500-hp hydroelectric plant, using Pelton wheels under 876-ft head, the record for high head at that time. Due to the fluctuation of the hoisting load on the power plant speed regulation of the water wheels became a serious problem and after some unfortunate experience with early hydraulic governors, Mr. Doolittle invented what was known as the "Doolittle differential governor" which was a success from the start and was used for more than 20 years. As the load increased it became necessary to conserve water and Mr. Doolittle invented a regulating nozzle which replaced the deflecting nozzles formerly employed. Mr. Doolittle became vice-president and general manager of the company and continued with the development of more hydroelectric power and its application to the mining industry in Aspen until 1905 when Mr. William Braden came to Aspen and persuaded Mr. Doolittle to go to Chile, South America, and install the hydraulic works to operate the first mill built by the Braden Copper Company, now part of the Kennecott holdings. This installation, consisting of water power for the concentrating mill and electric plant for mill and camp lighting, was completed in about one year's time though it was necessary to haul all of the machinery a distance of 45 miles into the mountains on 2-wheeled ox carts. After 1906 Mr. Doolittle returned to Aspen and developed further hydroelectric power for pumping the underground waters from the mines. Mr. Doolittle made his home in Aspen, Colorado, continuously except for several brief periods away on consulting work until 1923, when he was forced, by ill health, to retire from active practice and has lived in Glendale, Calif., until the time of his death.

Samuel Reber (A'93, M'96, F'12, and member for life) general foreign representative of the Radio Corporation of America, New York, N. Y., and vice-president of Radio Corporation of America Communications, Inc., died in Washington, D. C. April 16, 1933. He was born in St. Louis Mo., in 1864. He graduated from the U.S Military Academy in 1886, studied electrical engineering at Johns Hopkins University in 1894 and graduated from the Army War College in 1905. He was commissioned in the cavalry in 1886, remaining in this division until 1894 when he transferred to the signal corps. It was while he was in the signal corps that he helped survey the route of the proposed Nicaragua Canal. Between 1914 and 1916 he was chief of the army aviation section, then part of the signal corps. He reached the rank of colonel in 1916 and was retired at his own request in 1919. For a period after leaving the army in 1919, he was associated with the Columbia Syndicate, and in 1923 became associated with the Radio Corporation of America, being for a time director of traffic production for that company. He was in Japan during the 1923 earthquake and took charge of the reestablishment of communication by cable and wireless with the outside world. For this service he was decorated with the Fourth Order of the Rising Sun of Japan. He was a member of the electrical juries of the Chicago and St Louis exhibitions, and was a delegate to the following conferences: International Elec

trical Congress, 1893 and 1904; International Telegraph Conference in Paris, 1925; International Radio Telegraph Conference in Washington, 1927; and the World Engineering Congress in Tokyo, 1929. He was the author of various technical books and papers. He was an officer in the l'Etoile Noire, and held Indian War, Spanish-American War, Puerta Rican Campaign and Cuban campaign service medals, as well as the Victory Medal with 2 clasps issued in the World War. Colonel Reber was a member of the Institute of Radio Engineers and the Franklin Institute.

HAROLD WHITMORE SMITH (A'11, M'17) until June 1932 generating apparatus manager of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., died in Pittsburgh, March 28, 1933, after a brief illness. He was born in Adelaide, South Australia, in 1886, and graduated from the University of Adelaide with the degree of bachelor of science in 1906. In 1908 he received the degree of mechanical engineer from Cornell University, Ithaca, N. Y., and later took special summer courses at Columbia University, New York, N. Y. Between 1908 and 1909 he was on an apprentice course with the Wagner Electric Manufacturing Company, and in 1909 entered the 2-year apprentice course of the Westinghouse Electric and Manufacturing Company at East Pittsburgh. In 1911 he was transferred to the sales department of the company with headquarters in Milwaukee, Wis. Later that year he went with the Chicago, Lake Shore and South Bend Railway Company on erection work, and in 1912 became engineer draftsman with the San Diego Gas and Electric Company, San Diego, Calif. In 1913 he returned to Australia where he was for a few months electrical salesman and engineer with Noyes Brothers, Sidney, after which he was an electrical engineer in the department of home affairs of the Commonwealth Government of Australia, being located at Melbourne. In 1917 he again returned to the United States entering the general engineering department of the Westinghouse Company, and the next year entering the generating apparatus sales department. In 1924 he became an American citizen, subsequently becoming generating apparatus manager for the company.

PARK ELLIOTT (A'23, M'30) field engineer with the General Electric Company, New York, N. Y., died April 18, 1933, after a brief illness. He was born in Dover, Maine, in 1887, and received the degree of B.S. in E.E. from the University of Maine in 1915. From 1915 to 1916 he was in the test department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and from 1916 to 1919 was engaged in traffic engineering for the New York Telephone Company, except for a period of several months during 1918 when he was radio engineer with the U.S. Army. In the fall of 1919 he entered the organization of the General Electric Company at Pittsfield, Mass., where he was engaged as a transformer designer, heating specialist, insulation specialist, feeder regulator designer, and special transformer designer. Subsequently he was transferred to the New York office as field engineer engaged on special problems relating to transformers and regulators.

NORMAN MARSHALL (A'02, M'28) consulting engineer, Still River, Mass., died in New York, N. Y., March 28, 1933. He was born in Hampstead, N. H., in 1864, and graduated from Worcester Polytechnic Institute, Worcester, Mass., in 1886. From 1886 to 1889 he was employed by the Marr Construction Company, installing electric light and power plants in various sections of the country. He then was engaged in the construction of central station plants for the Westinghouse Electric and Manufacturing Company, and in 1890 was New England district engineer for the Westinghouse company, with headquarters in Boston, Mass. He began business for himself, manufacturing electrical fittings, sockets, switches, etc., in Philadelphia, Pa., in 1891, removing to Boston in 1893 to continue the same business. Between 1909 and 1926, he was engaged in manufacturing electrical insulating tubes, inventions, and consultation. From 1916 to 1918 in connection with the science and research department of the War Department, and jointly with the late Dr. Louis Bell, he invented and perfected ultra-violet signaling apparatus for use during the war. In 1927 he undertook practice as a consulting engineer. Mr. Marshall was well known for his inventive activities, having been granted some 45 patents having commercial value.

Local Meetings

New York Student Branch Convention Held

On Friday, April 28, 1933, the New York Section held its Student Branch convention. This meeting is held annually in conjunction with the regular section meeting and is attended by students from the nine colleges within the section territory. The day's program was divided into 3 parts; the details of the morning and afternoon sessions were arranged entirely by the student committees. Points of engineering interest were inspected during the forenoon. At 3:00 p.m. a session was held in the engineering auditorium. Two speakers addressed the student audience of about 350. The first was Farley Osgood (A'05, F'12, and past-president) consulting engineer, who spoke on "Experience in Human Engineering." The second speaker, Dr. E. E. Free, also in consulting practice, in a talk entitled "Engineers in Business" outlined his views of what lies before the engineering graduate just entering the field and the part he will play in the next business cycle. Excerpts from Doctor Free's address are presented on p. 425–6 of this issue. Talking pictures of industrial processes also were shown. At 6:00 p.m. the students assembled at a nearby restaurant for supper. The officers and officers-elect of the Section were present, as were President Charlesworth, National Secretary Henline, and a group of prominent engineers from the metropolitan area.

The evening session opened at 8:15 in the engineering auditorium with Chairman T. F. Barton presiding. He presented the report of the tellers committee giving the results of the elections of officers for 1933–34. He then turned the meeting over to the Student chairman, J. G. Allison, of Pratt Institute. Mr. Allison called in turn on the 3 student finalists to make their presentations in competition for the Section prizes. The 3 speakers and their subjects were as follows: R. Ragazzini, College City of New York, "Static Stability Limits on an Artificial Transmission Line"; C. I. Bradford, Rutgers University, "Theoretical Discussion of the Measurement of Radio Frequency Power With the Electrostatic Wattmeter"; and D. A. Neary and W. Ramsey, New York University, on "The 3-Phase Induction Motor at Double Supply Paralleled Rotor and Stator." The officers-elect of the Section acting as judges awarded first prize to C. I. Bradford and second prize to D. A. Neary. The prize presentations were made by President Charlesworth.

The program for the convention was then brought to a close with an address by Dr. W. E. Wickenden (A'07, M'13), President of Case School of Applied Science, entitled "The Engineer and the New Deal."

Past Section Meetings

Akron

ELECTRIC CABLES, by F. V. Calbert, Genl. Elec. Co. Illus. March 16. Att. 40.

ELECTRIC SHOCK, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. April 11. Att. 40.

Atlanta

THE ENGINEER AND PUBLIC WELFARE, by Dean A. A. Potter, Purdue Univ., pres., A.S.M.E. Joint meeting with A.S.M.E. Sec. April 4. Att. 75.

Appointment of nominating committee. April 18. Att. 5.

THE BANKING SITUATION AS I SEE IT, by Haynes McFadden, editor, The Southern Banker. April 24. Att. 72.

Baltimore

THE CAUSE AND REMEDY OF DEPRESSION, by J. S. Lennox. Joint meeting with Engrs.' Club of Baltimore, A.S.C.E. and A.S.M.E.—Sectional April 6. Att. 250.

Various Theories of Circuit Interruption, by D. C. Prince, Genl. Elec. Co. Dinner. April 21. Att. 33.

Boston

Experiences During the Development of Electrical Engineering Since 1875, by Dr. A. E. Kennelly, Harvard Univ. Students from Harvard, Mass. Inst. of Tech., Northeastern, and Tufts colleges attended the meeting. April 11. Att. 130.

Chicago

Electrical Features of the New Chicago Post Office, by C. A. Carpenter, Graham, Anderson, Probst & White. Joint meeting with the Western Soc. of Engrs. April 24. Att. 80.

Cincinnati

Address by L. A. Friedlander, Dayton Rubber Co., on his trip to Germany in the Graf Zeppelin. Submarine Treasure Hunting With Underwater Lamps, by E. W. Beggs, Westinghouse Lamp Co. Joint meeting with Dayton Engrs.' Club. April 13. Att. 180.

Cleveland

David Lindquist, Otis Elevator Co., traced the development of elevators through the years. March 16. Att. 150.

Columbus

Recent Developments in Arc Welding, by J. F. Lincoln, Lincoln Elec. Co. Joint dinner meeting with student Branch of Ohio State Univ. April 28. Att. 80.

Connecticut

Motors With Mercury Arc Commutators, by O. K. Marti, and William Arthur, Allis-Chalmers Mfg. Co. Meeting at New Haven. April 24. Att. 74.

Dallas

Some Economic Considerations of Primary and Secondary Distribution System Design, by H. K. Blake, Genl. Elec. Co. March 20. Att. 81.

Arc Phenomena and Circuit Interrupters, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. April 25. Att. 40.

Denver

Power on the Spot, by C. F. McKelvey, Black & Decker. Dinner. March 17. Att. 17.

Measurement and Control of Synchronous Machine Torque Angle, by S. W. Hannah and A. E. Logan, Univ. of Colo.; Hysteresis Measurements, by P. Barth and J. C. Bellitti, Univ. of Denver; Geophysical Methods as Applied to Petroleum Prospecting, by R. F. Aldredge, Colo. Sch. of Mines; A Light Beam Transmitter and Receiver for Demonstration Purposes, by Hudson Fields, Colo. Agri. Col. Annual col. night, preceded by dinner. April 28. Att. 50.

Annual ladies' party. May 3. Att. 69.

Detroit-Ann Arbor

Modern Theories of the Composition of Matter, by Prof. A. H. Compton, Univ. of Chicago. Illus. April 18. Att. 700.

Erie

The Place of Sound in Electrical Engineering, by Prof. J. R. Martin, Case Sch. of Ap. Science. April 18. Att. 73.

Florida

Business meeting followed by inspection tour of station WRUF. April 13. Att. 14.

Fort Wayne

Recent Development in Transportation, by W. M. Guynes, Genl. Elec. Co. Dinner. April 20. Att. 45.

Houston

Arc Phenomena and Circuit Interrupters, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. April 24. Att. 135.

Iowa

New Frontiers Through Research in Engineering, by H. P. Charlesworth, asst. chief engr, A. T. & T. Co., pres., A.I.E.E. Dinner. April 19. Att. 50.

Ithaca

Straight Thinking, by C. F. Hirshfeld, Detroit Edison Co. April 27. Att. 161.

Electric Welding, by J. F. Lincoln, Lincoln Elec. Co. May 8. Att. 75.

Kansas City

Arc Phenomena and Circuit Interrupters, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. April 20. Att. 110.

Louisville

C. W. Fick, Genl. Elec. Co., outlined some of the latest developments in the Genl. Elec. lab. March 16. Att. 85.

Madison

Discussion of the development of the practice of present-day utility regulation by A. B. Guillou, Wisconsin Pub. Serv. Co. Dinner. April 12. Att. 38.

Memphis

Transmission of Power, by C. Spencer Marsh, U.S. Veterans Bureau. April 18. Att. 36.

Mexico

Modern Illumination Considered Under Three Points of View, by E. S. Morales, Genl. Elec. Co. Illus. April 20. Att. 55.

Milwaukee

The Engineer's View of the Economic and Industrial Situation, by Arthur Simon, Wm. Kircaldie, E. D. Roberts, H. D. Hutchinson, Walter Ferris, and Werner Lehman. Joint meeting with Engrs. Soc. of Mil. Feb. 13. Att. 225.

Simplified Speed Control for Single Phase Locomotives, by W. A. Geiger, Allis-Chalmers Mfg. Co. Feb. 22. Att. 85.

Objectives of Electronic Engineers in Utility and Industrial Fields, by C. Stansbury, Cutler-Hammer, Inc.; Some Application of Electronic Apparatus in Industrial Control, by G. C. Brown, Cutler-Hammer, Inc. Joint meeting with Engrs. Soc. of Mil. March 15. Att. 230.

New Frontiers Through Research and Engineering, by H. P. Charlesworth, asst. chief engr, A. T. & T. Co., pres., A.I.E.E. Dinner. April 13. Att. 125.

What Should Colleges of Engineering Train for? by Dr. E. R. Stoekle and Prof. L. F. Van Hagen; What Are the Opportunities for Graduates of Colleges of Engineering? by T. C. Hatton and James L. Ferebee; What the Industries Have a Right to Expect of the Engineering Profession, by J. Wanvig and H. Falk; What the Engineering Colleges Have a Right to Expect From Engineering Profession and From Industry, by R. L. Cooley and Dr. J. D. Ball. Joint meeting with the Engrs. Soc. of Mil. and the faculty of the Univ. of Wis. April 28. Att. 110.

Modern Application of the Vacuum Tube, by S. Snead, Univ. of Wis.; An Investigation of Electronic Oscillation, by J. L. Rennick, Marquette Univ.; Parallel Operation of Over-Compounded Generators Without an Equalizer Bus, by Wm. H. Treadway, Milwaukee School of Engg. Election of officers: K. L. Hansen, chmn.; J. A. Potts, secy.; Sam Snead, and C. D. Brown, directors. May 3. Att. 75.

Minnesota

Talk by Dr. Ellis Manning of the Genl. Elec. Co. March 15. Att. 200.

Nebraska

The Design and Construction of a Beat-Frequency Oscillator Using Stabilized Oscillators and Duo-Diode Detection, by Walter Houck, Univ. of South Dakota; The Design and Construction of a High-Voltage Cathode-Ray Oscillograph and Linear Time Axis Device, by G. DeBey and Norman Larson, Univ. of So. Dakota. New Frontiers Through Engineering and Research, by H. P. Charlesworth, asst. chief engr., A. T. & T. Co., pres., A.I.E.E. Dinner. April 19. Att. 181.

New York

Dividing Up and Monitoring the Ether, by Dr. C. B. Jolliffe, Federal Radio Comm. Communication Group. March 14. Att. 275.

Lightning in Relation to Transportation, by D. R. McLeod, Genl. Elec. Co. Transportation group. April 6. Att. 75.

Modern Power Plants, by J. E. Goodale, N. Y. & Queens Elec. Lt. & Pwr. Co., and L. E. Frost, Brooklyn Edison Co. Inc. Inspection trips and dinner. Power Group. April 13. Att. 575.

New Devices for Control of Light, by A. H. Lamb, Weston Elec. Instrument Co.; I. C. Diefenderfer, Genl. Elec. Co.; R. C. Hitchcock, and N. L. Freeman, Westinghouse Elec. & Mfg. Co. Illumination Group and N. Y. Section of I.E.S. April 18. Att. 325.

Niagara Frontier

Phanotron Rectifier, by P. M. Currier, Genl. Elec. Co.; Membership, by J. Allen Johnson, Buffalo, Niagara & Eastern Pwr. Corp., vice-pres., A.I.E.E. Election of officers: J. S. Henderson, chmn.; F. S. Wahl, vice-chmn.; J. F. Oehler, secy. April 17. Att. 70.

North Carolina

Operation of Storage Batteries, by J. L. Woodbridge, Elec. Storage Battery Co.; Condensers as Storage Batteries, by T. J. Garrett, student, Duke Univ.; Load Dispatching, Duke Power Company's System, by C. M. Schoonover, Duke Pwr. Co. Inspection of Duke Univ. and informal dinner preceded address by W. S. Lee, Duke Pwr. Co., past-pres., A.I.E.E., entitled The Engineer's Relation to the Public. Joint meeting with Duke Univ. Branch. April 7. Att. 110.

Oklahoma City

Arc Phenomena and Circuit Interrupters, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. Dinner. April 21. Att. 110.

Philadelphia

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. April 10. Att. 275.

Portland

Trends in Electrical Engineering, by C. R. Higson, Utah Pwr. & Lt. Co., vice-pres., A.I.E.E., and Prof. A. L. Taylor, Univ. of Utah. Dinner. April 18. Att. 44.

Providence

High Tension Fuses, presented by representatives of Schweitzer Conrad, Inc., Genl. Elec. Co., and Westinghouse Elec. & Mfg. Co. Joint meeting with Boston Sec. March 14.

Recent Developments in the Wire and Cable Industry, by Donald M. Simmons, Genl. Cable Corp. Dinner. April 11. Att. 45.

The Control of d-c Motors With Thyratrons, by L. M. Lang, R. I. State Col.; The Cathode-Ray Oscillograph as a Television Receiver, by W. A. Downes, R. I. State Col.; A Study of Mercury Switches, by H. L. Anderson and E. L. Angell, Brown Univ.; A Study of the Telegraphone, by G. A. Freeman and N. G. Levesque, Brown Univ.; Photoelectric Cell Damper Control, by H. W. Memmott and H. H. Mohrfeld, Brown Univ.; Laboratory Methods of Maintaining Constant Speed, by W. Bojar and F. N. Cart, Brown Univ. L. M. Lang, R. I. State Col., was awarded first prize, which consisted of one yrs dues for Associate membership in the A.I.E.E. Joint meeting with R.I. State Col. Branch and Brown Univ. April 25. Att. 65.

Rochester

How to Choose a Radio, by Lee McCanne, Stromberg-Carlson Tel. Mfg. Co. Joint meeting with I.R.E., and Rochester Engg. Soc. April 6. Att. 82.

St. Louis

Arc Phenomena and Circuit Interrupters, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. Election of officers: L. S. Washington, chmn.; E. G. McLagan, vice-chmn.; B. F. Thomas, secy.-treas. April 19. Att. 132.

San Antonio

Modern Elevators, by F. H. Cunningham, Otis Elev. Co. March 24. Att. 21.

San Francisco

Radio Communication in Aeronautics, by J. H. Russell, Univ. of Santa Clara; Summary of Corona Loss Variations With Controlled Atmospheric Conditions, by G. Wesley Dunlop, Stanford Univ.; The Design of a Photoelectric Musical Instrument, by C. J. Miller, Univ. of Calif. G. Wesley Dunlop, Stanford Univ., received a prize of one yrs dues for Associate membership in the A.I.E.E. Joint meeting with Univ. of Santa Clara, Stanford Univ., and Univ. of Calif. Branches. April 13. Att. 75.

Saskatchewan

A Motor Trip Through the Western States, by R. N. Blackburn. March 31. Att. 50.

Lightning Protection With Special Reference to the Use of Surge Absorbers, by A. B. Cooper, Ferranti Elec., Ltd., director, A.I.E.E. April 24. Att. 30.

Sharon

Distribution Problems and Their Effect on Cost, by T. C. Dee, Ohio Edison Co. Film—"Out of the Shadow." April 11. Att. 107.

Springfield

Our Patent System, by Chester T. Neal, Chapin & Neal. April 10. Att. 45.

Toledo

Executive Committee meeting. April 5. Att. 8.
Theory and Operation of the Diesel Engines, by Mr. Biggs, Rathbun-Jones Co. April 28. Att. 120.

Toronto

Recent Progress in Research, by Thomas Spooner, Westinghouse Elec. & Mfg. Co. Joint meeting with Engg. Inst. of Canada. April 21. Att. 200.
Northern Ontario, by L. V. Rorke, Department of Surveys of Ontario. Ladies' night. April 28. Att. 67.

Urbana

Electrons in Overalls, by E. S. Darlington, Genl. Elec. Co. Illus. Joint meeting with Univ. of Ill. Branch. March 16. Att. 212.
The Solar Eclipse of 1932, by Alfred Herz, Pub. Serv. Co. of No. Ill. Joint meeting with Univ. of Ill. Branch. April 5. Att. 262.
Mazda Preferred, by C. R. Stover, Genl. Elec. Co. Moving pictures. Joint meeting with Univ. of Ill. Branch. April 26. Att. 350.

Utah

Automatic Electrical Control for Heating and Ventilating Systems, by G. C. Campbell, Campbell, Elsey, Burnett. April 17. Att. 16.

Washington

The Measurement of High Voltages at Commercial Frequencies, by F. M. Defandorf, Bureau of Standards. Film—"Out of the Silence." Dinner. April 11. Att. 85.
The Production and Measurement of Short Time Intervals, by H. G. Dorsey, U.S. Coast and Geodetic Survey. Election of officers: Roland Whitehurst, chmn.; H. G. Dorsey, vice-chmn.; G. G. Coleman, secy.-treas. May 9. Att. 75.

Worcester

Relays, by Theodore Braaten, Westinghouse Elec. & Mfg. Co. March 18. Att. 20.

Past Branch Meetings

Alabama Polytechnic Institute

Technocracy and Its Relation to Engineering, by L. E. Curtis; Mathematical History, by R. W. Wages, students, Feb. 23. Att. 30.
High Temperature Insulation, by Prof. C. Hixon. March 9. Att. 27.

University of Alabama

Latest Uses of Thyratron Tubes, by V. Lariton; Radio, by T. Stravas, students. Inspection trip to Mitchell Dam. April 17. Att. 22.
Efficiency by Power Factor Control, student. Election of officers: H. G. Galloway, chmn.; A. J. McCullough, vice-chmn.; N. J. Santello, secy.; F. B. Gaines, treas. April 24. Att. 25.

University of Arkansas

Hoover Dam, by Russell Stone, Frank Davis, and E. Howell, students. March 9. Att. 24.
Is the Engineer Responsible for Present Economic Conditions? by L. C. Wasson, student; This and That, by Prof. W. B. Stelzner, counselor. April 11. Att. 27.
Flux Distribution, by G. C. Sherlin; Economic Problems, by R. Cope; Electrical Characteristics of Driven Grounds, by C. L. Mowery, students. April 27. Att. 22.
Election of officers: Frank Davis, chmn.; E. A. Howell, vice-chmn.; Robert Boyd, treas.; Barnette Robinson, secy. May 4. Att. 22.

Armour Institute of Technology

Factory Methods in the Construction of Radio Tubes, by Mr. Brian, Grigsby Grunow Co. March 31. Att. 43.

University of British Columbia

Election of officers: H. E. Sladen, chmn.; W. G. A. Barr, secy.-treas. April 7. Att. 17.

Polytechnic Institute of Brooklyn

Films—"A Modern Hydroelectric Power Plant" and "Installing Primary Network Equipment." April 19. Att. 35.

Bucknell University

Electric Clocks, by Prof. G. A. Irland, counselor. Election of officers: H. D. Ruger, chmn.; H. Smithgall, Jr., vice-chmn.; Forrest Francis, secy.-treas. April 26. Att. 20.
James Dobbie and Mr. Windes, students, gave a summary of work in vector analysis being carried on by them. May 2. Att. 25.

California Institute of Technology

Moving pictures. April 14. Att. 160.

University of California

Power Load Dispatching, by W. D. Skinner, Pacific Gas & Elec. Co. April 6. Att. 35.
Joint meeting with San Francisco Section. (See report under "Past Section Meetings.") April 13. Att. 75.
Inspection trip to the Pacific Coast plant of the RCA Communications, Inc. April 15. Att. 30.
Discussion and election of officers; L. W. Sepmeyer, chmn.; D. R. Tibbetts, vice-chmn.; Ted Lyman, secy.; W. H. Carlson, treas. April 18. Att. 11.

Carnegie Institute of Technology

Lightning—A Split Second Phenomenon in Electrical Engineering, by B. M. Fritz and R. B. Hanna, students. April 26. Att. 21.

Case School of Applied Science

The Engineer and the New Deal, by Dr. W. E. Wickenden, pres. April 19. Att. 65.
The Effect of Quality and Intensity of Artificial Light Upon Seeing, by L. B. Moore; Impedance Characteristics of Rochelle Salt, by W. J. Lattin, students. X-Rays and Their Industrial Applications, by Dr. Kent Van Horn, Aluminum Co. of Am. Joint meeting with Cleveland Section. April 20. Att. 130.
Election of officers: J. R. Donnell, chmn.; C. Cotman, vice-chmn.; W. Davidson, secy.-treas. May 3. Att. 26.

Clemson Agricultural College

The Reading Railroads Suburban Electrification, by W. J. Burton; Mercury Rectifiers Versus Rotary Converters, by J. R. Garaty; Economic Conditions and the Engineer, by W. H. Gist; Current Events, by D. E. Penny, students. March 28. Att. 42.
Cosmic Rays, by D. E. Penny; Current Events, by C. M. Henley, students. April 25. Att. 45.

Colorado Agricultural College

The Use of the X-Ray in the Study of Molecular Structure, by Dr. F. P. Golder. April 10. Att. 11.
The Proposed Ft. Collins Municipal Light Plant, by B. G. Coy, city engr. April 24. Att. 16.

University of Colorado

The Operation and Installation of the Electrical and Mechanical Machinery at the Climax Molybdenum Co., by O. N. Parker, student. April 5. Att. 25.
Photoelectric Cells, by R. H. Maxwell, Westinghouse Elec. & Mfg. Co. April 17. Att. 200.

Cornell University

Power Arcs, by K. W. Ashman; Supervisory Systems of Remote Control, by J. F. Carmody, students. April 14. Att. 14.
Electric Welding, by J. F. Lincoln, Lincoln Elec. Co. Election of officers: K. C. White, chmn.; S. A. Voelker, secy.-treas. May 8. Att. 75.

Drexel Institute

Battery Design and Production Methods, by G. W. Proctor, Emork Battery Co. Joint meeting with A.S.M.E. branch. April 12. Att. 25.
A Modern Electric Power System, by F. R. Ford, Phila. Elec. Co. Election of officers: J. P. Breickner, chmn.; J. S. Franklin, vice-chmn.; A. C. McCoy, secy.; E. C. Russell, treas. April 26. Att. 17.
Inspection trip to the Dewey automatic switching exchange of the Bell Telephone Co. April 27. Att. 42.
Power Supply Problems in a-c Receiver Design, by J. I. Carnell, RCA Victor Co. May 10. Att. 23.

George Washington University

Electrical Research Engineering in the Navy, by L. P. Wheeler, U.S. Navy. March 6. Att. 13.
The Vacuum Tube as a High Frequency Oscillator, by F. Grimes; The History of Commercial Radio Receiver Design, by J. Channel, students. April 11. Att. 16.

Georgia School of Technology

Film—"Thomas Edison in the General Electric Plant." Feb. 21. Att. 40.
The Engineer and Public Welfare, by Dean A. A. Potter, Purdue Univ., Pres., A.S.M.E. Talks by Dr. Brittain, pres., Georgia School of Tech., and Ex-Gov. Osborn of Mich. April 4. Att. 56.
Motion pictures. April 25. Att. 35.
Inspection trip. May 1. Att. 33.

Harvard University

The Art of Cross Examination, by D. E. Hall, Hulburt, Jones, and Hall. April 25. Att. 115.

University of Idaho

Business meeting. Feb. 23. Att. 33.
Motion pictures. March 16. Att. 42.
Rates, by Mr. Pike, Wash. Water Pwr. Co. Dinner. April 6. Att. 39.

University of Illinois

Electrons in Overalls, by E. S. Darlington, Genl. Elec. Co. Joint meeting with Urbana Sec. March 16. Att. 212.
The Solar Eclipse of 1932, by Alfred Herz, Pub. Serv. Co. of No. Ill. Joint meeting with Urbana Sec. April 5. Att. 262.
Mazda Preferred, by C. R. Stover, Genl. Elec. Co. Moving pictures. Joint meeting with Urbana Sec. April 26. Att. 350.

Iowa State College

Discussion. Feb. 15. Att. 34.
Vacuum Tubes, by John Foster, student. March 2. Att. 41.
Production of Carbon Black, by Prof. O. A. Brown; Electric Railway Signals, by V. M. Dyer, student. Talks by Mr. Evans and Mr. Johnson, students, on the progress in their thesis work. April 20. Att. 32.

University of Iowa

The Iowa State Board of Engineering Examiners, by Prof. G. J. Keller. April 19. Att. 32.
W. Van Haitsma, Boeing School of Aeronautics, presented films showing the development of air transportation and activities in the Boeing Sch. April 26. Att. 82.

Kansas State College

Report of Water Resources of Kansas, by G. S. Knapp, Div. of Water Resources of Kan. March 2. Att. 80.
Relation of Business to Engineering, by Harry Bouck, Chamber of Commerce. April 16. Att. 80.
Discussion. April 20. Att. 40.

University of Kansas

Railway Electrification, by Capt. W. J. Burke. March 23. Att. 44.
Annual banquet. April 7.
Discussion. April 21. Att. 26.

Lafayette College

Election of officers: Robert Blum, chmn.; L. T. Johnson, secy. April 26. Att. 20.

Lewis Institute

Business meeting. April 19. Att. 30.

University of Louisville

An Engineering Romance, by Prof. W. E. Freeman, Univ. of Louisville, vice-pres., A.I.E.E. April 21. Att. 19.

Marquette University

An Investigation of Electronic Oscillations, by J. L. Rennick, student; Photo-Cell and Its Uses, by Mr. Kirkish, student. April 20. Att. 20.
Election of officers: G. J. Griffith, chmn.; W. C. Fischer, vice-chmn.; G. A. Loew, secy.; J. L. Rennick, treas. May 4. Att. 18.

Massachusetts Institute of Technology

Dial Telephone Systems, by G. K. Burns, student. March 21. Att. 21.
Experiences During the Development of Electrical Engineering Since 1875, by Dr. A. E. Kennelly, Harvard Univ. Joint meeting with Boston Section and the student branches at Harvard Univ., Northeastern Univ., and Tufts Col. April 11. Att. 130.

Michigan College of Mining and Technology

Trends in Electrical Engineering, by F. H. Farmer, Westinghouse Elec. & Mfg. Co. Film—"Dynamic America." April 13. Att. 55.

Michigan State College

Some Phases of Interest in Law, by J. E. Converse, asst. atty. genl. of Mich. April 26. Att. 17.

University of Michigan

Theory of the Electric Arc and Its Application to Circuit Breakers, by Dr. G. S. Timoshenko. April 24. Att. 17.

University of Minnesota

The Electric Power Development in England, France, and Germany, by Prof. W. T. Ryan; Discussion of the Electrical Show, by Parker Lowell, student. April 11. Att. 68.

Tenth biennial electrical engineering party. April 28–29. Att. 8,300.

Mississippi State College

Business meeting. April 12. Att. 27.

University of Missouri

Television, by G. L. Taylor, Natl. Television Sch. April 27. Att. 41.

Montana State College

Electrochemical Processes Increasing, by F. Liquin; Improving Customer Contact, by H. E. Murdock; Electric Developments in Aviation, by L. Peterson; Combating Rust With Metallic Finishes, by B. Roberts; What the Tests Show, by G. W. Roberts, students. April 13. Att. 60.

Gaseous Discharge Lamps and Their Application, by O. R. Lester; Ole's Trip Through the Substation, by D. C. Shevalier; Automatic Arc Welding With Atomic Hydrogen, by R. L. Spaulding; Sandwich Type of Road Built With Bituminized Cement, by E. Watts; Motoring a Ditch Dredger, by A. White, students. April 20. Att. 49.

Electrical demonstrations. April 27. Att. 70.

Films—"The Queen of the Waves" and "The King of the Rails." May 4. Att. 135.

University of Nebraska

Five Meter Transmission, by M. W. Bullock and W. Koch, students. April 26. Att. 31.

University of Nevada

W. C. Smith, Genl. Elec. Co., outlined recent developments in electrical engineering. April 19. Att. 25.

Newark College of Engineering

Transformer Oil, by W. C. Gegenheimer; Photo-Cells, by J. S. Bodjo; High Speed Excitation, by W. A. Moody, students. March 13. Att. 18.

The Gyroscope and Its Practical Applications, by O. B. Whitaker, Sperry Gyroscope Co. April 3. Att. 23.

University of New Hampshire

Edward Rath outlined problems that he has encountered in his work as a research engineer. April 1. Att. 30.

Safe Harbor-Westport 230 Kv Transmission Line, by J. E. Smet; Sound Recording by Light Valve System, by B. H. Booth; Economic Aspects of Water Power, by E. W. Hitchcock and H. W. Feindle, students. April 8. Att. 28.

The Rotary Voltmeter, by R. C. Loeschner; Higher Steam Pressures and Temperatures a Challenge to Engineers, by H. T. Dickson and L. M. Partridge, students. April 15. Att. 28.

Technical Features of the New General Electric Oil Furnace, by A. E. Allen; Lightning Experience on Wood Pole Lines, by C. W. Quimby and E. Priest, students. Election of officers: O. Abbiati, pres.; L. M. Partridge, vice-pres.; E. W. Hitchcock, secy. April 22. Att. 31.

Reactive Power in Need of Clarification, by E. Horne; Operating Aspects of Reactive Power, by E. L. Huse; Reactive and Fictitious Power, by H. J. Joyal, students. April 29. Att. 26.

University of New Mexico

Electric Arc Welding, by M. M. Zirhut, student. April 11. Att. 7.

New York University

Insulated Babies, by Walter Christie; The Raman Effect, by J. Delmonte; Super-Conductivity in Metals, by E. Lobo; Pale Horror, by E. Schmidt; Communication in the Army Signal Corps, by K. Dumond, students. April 7. Att. 21. [Ed. Note: Titles as reported]

North Carolina State College

Discussion. May 2. Att. 28.

University of North Carolina

The Inspection Trip Made by the Senior Class in Charlotte, N. C., by W. G. Miller, student. The Place of the Engineer in Industry, by Mr. McConnell, Burlington Mills. Feb. 22. Att. 24.

Lighting for the Future, by R. A. Palmer, Southern Public Utilities Co. Illus. March 1. Att. 30.

The General Features of the Chute-A-Caron Hydroelectric Development, by J. D. Watson. The Details of the Experiments Conducted to Determine the Correct Design of the Chute-A-Caron Obelisk, by J. R. Marvin, student. Joint meeting with A.S.M.E., A.S.C.E., and A.S.Ch.E. Branches. April 13. Att. 60.

University of North Dakota

General discussion. April 5. Att. 32.

The Wireless Part of Radio, by Robert Moore; Artificial Sunlight, by D. Haagensen, students. April 12. Att. 15.

Civilization and the Engineer, by Prof. D. R. Jenkins. April 20. Att. 101.

Plans for Engineers Day, by Albert Stratmoen, student. May 3. Att. 20.

University of Notre Dame

Life of Steinmetz, by Charles Mueller, student. Telephony, by Mr. Bolt, Indiana Bell Tel. Co. April 26. Att. 55.

Ohio Northern University

Development of the Electrical Industry, by John Riss, student. March 9. Att. 15.

History of the Electrical Industry, by Mr. Stiles and Mr. Schneider, students. April 20. Att. 26.

Election of officers: Clayton Allen, pres.; Carl Fox, vice-pres.; John Hartle, secy.; Clarence Jacobs, treas. April 27. Att. 21.

Ohio State University

Election of officers: John Silver, chmn.; Robert Beetham, secy.-treas. April 6. Att. 30.

Ohio University

Films—"The Electric Ship" and "The Radio." Election of officers: Paul Matthaes, chmn.; Raymond Fenwick, vice-chmn.; Eugene Pryor, secy.-treas. April 27. Att. 13.

Oklahoma A. & M. College

Illumination and Photo-Electric Cells, by W. K. Richey; Mercury Arc Rectifiers and Commutatorless Motors, by J. R. Hollis, students. March 27. Att. 33.

Aviation Radio, by Forest Himes, student. Election of officers: Calvin Hanan, chmn.; Earl Payne, vice-chmn.; Dillon Martin, secy. April 10. Att. 32.

Oregon State College

The Past, Present, and Future of Illumination, by F. M. Murphy, Portland Genl. Elec. Co. April 13. Att. 33.

Pennsylvania State College

Symmetrical Components, by C. B. Holt. April 7. Att. 22.

Election of officers: J. D. Colvin, pres.; C. C. Cooner, secy.; D. G. Brubaker, treas. April 27. Att. 24.

Inspection trip to the Bellefonte airport. April 27. Att. 34.

University of Pennsylvania

Wings of the Future, by J. Miller, Pitcairn Aircraft Corp. March 2. Att. 14.

University of Pittsburgh

Some Defects in Our Present Educational Systems, by R. H. Kernahan; A Sure Cure for Our Present Depression, by R. E. Morell, students. April 27. Att. 105.

Unemployment Caused by the Increased Use of Machines, by C. M. Harnish; The Need of an Avocation, by J. K. Brownlee, students. May 4.

University of Porto Rico

Industrial Applications of Electricity, by Prof. M. Wiewall, Jr.; Applications of Mathematics to Electrical Engineering, by O. P. Diria, student; Advantages of Joining the A.I.E.E., by Prof. G. F. Anton, counselor; Application of Electricity to Plant Breeding, by R. L. Davis, U.S. Agricultural Experiment Station. March 31. Att. 36.

Annual dinner meeting. April 23. Att. 35.

Pratt Institute

Electronics, by O. H. Caldwell, editor Electronics. March 23. Att. 335.

Purdue University

An Improved Cathode-Ray Oscillograph, by H. F. Mayer; Precise Measurements of High Frequency, by J. W. Hammond; Demonstration of High Voltage Phenomena, by C. S. Sprague; Television, by E. M. Purcell; R. H. George, and H. J. Heim; Demonstration of Modern Duplex Radiotelephone Communication, by Prof. G. E. West and John W. Hammond; Nomography and Special Slide Rules, by J. N. Arnold; High Frequency Demonstration, by J. E. Hobson, C. R. Steen, F. H. Roby, and C. H. Hunter, students. Address by Prof. C. F. Harding, head, School of Engg., and banquet. Joint meeting with Ind.-Laf. Section, and the Univ. of Ill. and Rose Poly. Inst. Branches. April 29. Att. 250.

Rensselaer

Some Problems in Toll Transmission, by B. K. Boyce, N. Y. Telephone Co. Election of officers: W. C. Stoker, chmn.; A. J. Bujarowicz, vice-chmn.; R. L. Ringer, secy.-treas. April 18. Att. 300.

Rice Institute

Mr. Shofstall, student, outlined his experiences while working with the Genl. Elec. Co. April 7. Att. 19.

Rose Polytechnic Institute

Circuit Interruption, by G. T. Lautenschlager; Amateur Radio Transmission, by C. E. Grogan, students. April 18. Att. 31.

Rutgers University

The Application of the Quadrant Electrometer to the Measurement of Radio Frequency Power, by C. I. Bradford, student. April 25. Att. 26.

University of Santa Clara

Election of officers: H. E. Kinerk, chmn.; Manning Hermes, vice-chmn.; Michael Victor, secy. May 2. Att. 16.

University of South Carolina

The Truth About High-Altitude Flight, by Mr. Nicholson; Modern Signaling on the Reading Railroad, by K. Sease; Wonder of Man Made Lightning, by Wm. Shannon, students. April 10. Att. 35.

The Development of the Wireless Telegraph and Wireless Telephony, by J. Taylor; Lighting in the Theatre, by W. J. Valentine; The Effect of Ultra-Violet Radiation Upon the Eye, by R. D. Wannamaker, students. April 24. Att. 33.

Election of officers. May 1. Att. 18.

South Dakota State School of Mines

Meter Testing and Experiences as a Meter Tester, by H. F. Fuhlbrugge, Northwestern Pub. Serv. Co. March 1. Att. 18.

Academic Life at West Point, by Lieut. Trauer, U.S. Army. April 26. Att. 39.

Syracuse University

Arguments for Public Ownership, by R. Bradshaw and H. Klotz; Synchroscopes, by J. Y. Howard, students. April 11. Att. 23.

Reducing Substation Costs by the Use of Remote Control, by D. Grigson; The History of Electrical Power, by N. F. Emig; Glow Lamps for Home Lighting, by L. E. Dawley, students. April 28. Att. 23.

University of Tennessee

Corona Losses in High Tension Lines, by H. H. Gnuse, Jr.; Electronics, by L. G. Cockrill, students. March 29. Att. 17.

Motion pictures. Election of officers: Wm. Dean, Jr., chmn.; John Wellborn, vice-pres.; Edward Arnn, secy.-treas. April 12. Att. 14.

The Proposed Cove Creek Dam and Its Possibilities, by Prof. Switzer. May 3. Att. 21.

University of Utah

Uses of Electricity in Medicine, by Dr. J. U. Giesy. April 14. Att. 60.

University of Vermont

Thomas Reeves, student, described the electrical equipment on the dirigible Macon; G. W. Patterson, student, described the Russian Dneiper River hydroelectric development. April 3. Att. 17.

Electrification of the Reading Railroad,

by L. Merrihew; THE ROCKY RIVER HYDROELECTRIC DEVELOPMENT, by E. S. Judkins, student. April 17. Att. 16.

NORTHERN LIGHTS, by W. N. Coburn; POWER LINE COMMUNICATION SYSTEMS, by F. P. Kenyon, students. April 24. Att. 18.

University of Virginia

THE ENGINEER'S REWARDS, by C. R. Brandt; A STUDENT'S VIEW OF THE A.S.M.E. CONVENTION AT BIRMINGHAM, by E. Parker; A WIDER FIELD FOR ENGINEERS, by J. A. Grady; THE ENGINEER IN A CHANGING SOCIETY, by B. G. Switzer, students. April 27. Att. 71.

Virginia Military Institute

THE POWER SYSTEM OF WEST POINT, by B. G. Adkins; THE APPLICATION OF ELECTRICITY TO SEA TRAVEL, by W. P. Kimbrough; GAS FILLED AND VACUUM RADIO TUBES, by W. H. Turner; POWER TO BE USED IN THE BREWERIES, by R. S. Gilliam, students. March 18. Att. 72.

THE MODERN TREND IN STEAM ELECTRIC GENERATING DESIGN, by C. S. Betts; A NEW ELECTRONIC RECORDER, by J. Roberts; THE GRADUATE SCHOOLS OF HARVARD AND M. I. T., by L. B. Jones; A LOUISIANA DYNAMO, by J. M. Goodwyn, students. April 7. Att. 74.

WATER PROBLEMS SIMPLIFIED, by J. M. Matthews; THE EMPIRE STATE BUILDING, by C. A Penick; OIL ELECTRIC LOCOMOTIVES, by P. Nash; DECOMPOSITION OF ELECTROLYSIS, by J. M. Nimmo, students. April 29. Att. 75.

Virginia Polytechnic Institute

THE OBERHASLI HYDROELECTRIC DEVELOPMENT, by J. A. M. Maddox; RURAL ELECTRIFICATION, by J. W. Compton, students. April 13. Att. 29.

THE READING RAILWAY ELECTRIFICATION, by S. L. Butler, student. April 20. Att. 31.

ILLUMINATION, by G. B. Delote; ARC WELDING APPLIED TO STRUCTURAL PURPOSES, by W. P. Swartz; THREE CAUTIONS FOR ELECTRICAL WORKERS, by J. L. Brown; THE ELEMENTS OF Illumination, by G. Giles; SELLING LIGHT, by H. C. Epperly, students. April 27. Att. 32.

ELECTRIFICATION OF THE PENNSYLVANIA RAILROAD, by R. V. Creasy; THE MUSCLE SHOALS PROJECT, by W. H. Johnson, students. May 4. Att. 29.

State College of Washington

ELECTRIC SHIP DRIVES, by Prof. R. D. Sloan. April 4. Att. 34.

University of Washington

ROTARY VOLTMETER, by E. Schuchard, student. April 13. Att. 24.

DESIGN OF POWER RECTIFIERS FOR RADIO EQUIPMENT, by H. J. Price; MULTI-RANGE ELECTROSTATIC VOLTMETER, by Wm. R. Morse; DEMONSTRATION OF BARKHAUSEN HYSTERESIS EFFECT, by S. Hansen and G. K. Barger, students. April 18. Att. 60.

EMPLOYMENT PROSPECTS, by R. E. Thatcher, Puget Sound Pwr. & Lt. Co. April 27. Att. 32.

Washington University

CALCULATIONS FOR LEAKAGE REACTANCES OF TRANSFORMERS, by W. Godin, Maloney Elec. Co. April 15–25. Att. 29.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Appraisal

STATISTICAL CLERK, E.E., married, experienced in compiling engg and technical data, preparations of specifications, bldg. surveys and appraisal reports, miscellaneous estimating, field, shop inspections and testing of matl. and equip. Pleasing personality and good appearance. Must have work immediately regardless of character, location, or salary. D-2080

Construction

E.E. GRAD., 1915, 15 yr experience; 10 yr responsible charge design, switching and control large steam and hydro stations. Field supervision of constr. System studies. Relay applications. Desires position constr. or utility. Prefer location East of Mississippi. D-2064

GRAD. E.E., 30, 5 yr supervisory constr., design, estimating and field engg experience on superpower plants and substations; 4 yr industrial pwr. plant operation, elec constr., and maintenance experience; ry. electrification constr. experience. C-4428

Design and Development

E.E. for design, development, or research. B.S. and M.S. in E.E. from Univ. of Wis. Westinghouse engg school and meter dept. Experienced with well-known labs. in all kinds of elec testing. Some patent development experience on elevator signal apparatus and on metering apparatus. Available now. Any location. C-8875

B.S. in E.E., 33, single. Nine yr in engg dept. of elec measuring instrument concern, also 2 yr cooperative course, working in every dept. Experience in research, design, specification writing, and for 5 yr responsible for correct replies to all tech. inquiries. Available immediately. Prefer vicinity New York. D-2040

E.E. GRAD., B.S. Univ. of Calif. '20, married, desires position design and development new elec apparatus. Experience: 5 yr Bell System in development of telephone and signaling equip. 3 yr R.C.A. Victor design and development of radio apparatus, 4 yr with other radio mfrs. Available short notice. Location, East. D-2070

E.E.-MECH. ENGR, design and development of electromechanical devices. Research: physical tests of materials, metallography, X ray structure analysis. Languages: English, German, French. C-6994

MECH. ENGR with unusually broad experience in boiler, pwr., and industrial plant design and development, available on short notice. Has been most successful in developing going concerns from flow sheets and preliminary sketches. Location immaterial, but prefer South Eastern states. Married. D-1862

GRAD. E.E., 34, married, first class electrician, experience in this line work, installation, operation, and maintenance Diesel elec plants. Three yr Gen. Elec. Co., head of motor test floor; 4 yr design and field work for mfr. heavy machy. Location immaterial. D-2102-329-C-2-San Francisco

ENGR, 31, with 12 yr Bell System and govt. plant and field experience on sound picture, radio and telephone (manual, dial, repeater, and carrier current) systems. Design and development of manual and automatic elec testing equip. Industrial applications of electron tubes. Available immediately. C-9376

DESIGN ENGR, desires position in engg or teaching. B.S. in E.E. and design courses in Bell Lab. Experience: 4 yr development and application of outside plant apparatus for Bell System. Salary, location, open. Available upon notice. D-1305

ELEC DESIGNER, 33, married, equivalent of col. education; 15 yr experience on automatic ry. substations, 4 kv to 230 kv substations, hydroelectric and steam pwr. plant and low tension network systems. Available immediately. Location immaterial. B-8628

ELEC AIRCRAFT INSTRUMENT DESIGNER, 3 yr actual experience with temperature and speed meters. Broad education: B.A. math., B.S. in E.E. Depression wages acceptable, a growing connection wanted. D-2154

E.E. GRAD., Penn. State '29. Miniature instruments—aircraft specialty; 3 1/2 yr experience in development and mfg. Location immaterial. D-2055

E.E. and M.E. GRAD., married. Twenty-two yr experience design, construction pwr. plants, substations, transmission, distribution systems; 3 yr executive experience charge engg dept. large utility syndicate; 3 yr purchase engg equip. for foreign interest. Language English, German, Russian, Armenian, and Turkish. Available immediate service design, construction, operation, or purchasing. D-84

Executives

ADMINISTRATION, organization, investigations, planning. Nine years experience United States and abroad. Will work 2 wks. without pay to prove abilities. Location U.S. or foreign. C-3534

UTILITY ENGR, 31, 10 yr elec utility experience principally with client cos. of Elec Bond and Share, includes design, constr. and operation of transmission and distribution systems, investigations and economic studies, reconstruction and development planning, annual budgets, accounting and genl. engg work affecting more economical operation and maintenance of facilities. B-6934

COMMUNICATIONS ENGR Extensive U.S. and foreign experience design, constr., installation, operation and maintenance, tel., tel., and radio. Excellent references. Available soon. C-8805

PATENT ATTORNEY - DEVELOPMENT ENGR desires position with patent dept. or mfg. co., or as development engr with part time patent duties. Ten yr experience with mfg. co. and in private practice. Middle West preferred. Available 2 wks. notice. D-2091

POWER ENGR, steam-elec, 43, tech. education. Thirteen yr in operating and constr. engg of medium and large industrial steam-elec pwr. plants. Several yr pwr. engr in large copper refinery followed by several years with prominent engg organization. Available for report and rehabilitation work as well as for permanent position. D-986

EXECUTIVE, E.E. grad., married. Many yr experience as mgr., supt., elec engr for elec light and pwr. plants. Installed steam-Diesel and hydroelec plants. Bldg. substations, transmissions and distributing systems, street car and interurban

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

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network. Laying underground and undersea cables. Advg. mgr., sales representative for mfrs. of elec equip. B-2388

EXEC, ELEC; 40, married. Twenty-five yr utility experience; engg, constr., installation, operation, maintenance, pwr. plants, transmission and distribution systems, protection, metering, and consumer's equip. Also considerable development and research work. Desires executive position leading to mgmt. of utility or industrial concern. Location, U.S.A. D-2127

E.E., 35, 10 yr experience covering design, cost estimating and equip. specifications of pwr. plants, industrial bldgs., copper and oil refineries, substations and transmission lines. Also 1/2 yr as asst. research engr with cable co. and 1 yr as tester with elevator co. Licensed N. J. engr English and German languages. C-5473

EXEC. ASST. Mr. Chief Executive you need your time for bigger things. I will take your mfg. problems off your hands and operate your plant at lowest possible cost. I have done this in elec and mech. lines. Desire to get connected with firm where hard work and ability are appreciated. D-2076

GRAD. ENGR (B.E. elec), married, 29, 18 mos. utility experience New Zealand, 1 yr G.E. test course, 2 1/2 yr G.E. export. Excellent references. Position wanted tech. side utility, cons. engr or mfr. Location or country immaterial. D-2158

Industrial Engineer

ELEC CONTROL AND MAINTENANCE ENGR, 34, single, grad E.E., 12 yr elec maintenance, large eastern steel plant, charge of all motor control problems; 1 1/2 yr in Russia on new steel plant layout work as member of Am. firm. Desires position with elec mfg. or industrial organization. Excellent references. Available immediately. D-1953

Instruction

B.S., M.A., 37, 5 yr teaching experience, several yr in radio and research labs. Desires col. teaching position in electronics, radio engg or elec engg. Available in summer or fall. C-1087

E.E. GRAD., B.S. and M.S. Westinghouse grad. student, 4 yr teaching at Univ. of Neb., familiar with economics of engg. Good health, salary open, location immaterial. Needs industrial or teaching position. Available June 1933. D-445

E.E., 1928 grad., M.S. in E.E. Univ. of Pittsburgh. June 1933, single. 4 1/2 yr with Westinghouse, grad. student course and research labs. Engaged in fundamental research on a-c arc extinction problems, and in development and testing of circuit-interrupting apparatus. Several recent publications. Desires research, development, or teaching. Location immaterial. D-2093

E.E.-M.E., 35, Tau Beta Pi; 10 yr teaching; 5 yr engg faculty Cornell Univ.; 4 yr mfg. engr; one yr elec designer Stone & Webster; cons. E.E. constr. Boston traffic tunnel. Now teaching, minor tech. inst. Wants position teaching in col. or engr industrial or constr. co. C-5876

ENGG INSTRUCTOR, 33, single, M.E. and E.E. deg., specializing in mech. design, mathematics, etc., 4 yr instructor at Cornell Univ. followed by 5 yr practical design work for Allis-Chalmers. D-122

Junior Engineers

E.E. GRAD., Pennsylvania State Col., B.S. 1932, M.S. 1933, 23, single, member of Tau Beta Pi and Eta Kappa Nu. Knowledge of ry. traction and signaling. Ry. work preferred. Experience: Summer work as electrician and in P.R.R. signal dept. Good references. Location and salary secondary. Available after June 5th. D-2131

B.S. in E.E., 1933, Drexel Inst. Chairman, student branch, A.I.E.E. Member of Tau Beta Pi. Practical experience on telephone installation, transformer manufacture, substation construction, and elec ry. maintenance. Good references. Any type of work, any location. D-2130

DISTRIBUTION ENGR, B.E.E. Ohio State, 1931, desires position in distribution and transmission design and construction. One yr and 10 mos. utility experience on distribution and transmission problems with small Middle West pwr. co., also estimates and costs. Available immediately. Location immaterial. D-2128

M.Sc. in E.E. 1932; 25, single. Specialized in high-frequency circuit theory and vacuum tube analysis. Two yr teaching asst. Member Sigma Xi, Eta Kappa Nu. Capable of assuming responsibility. Desires position in industry. Excellent references. Salary secondary and location immaterial. Available at once. D-2132

E.E. GRAD. with B.S., Univ. of Calif., Tau Beta Pi, Eta Kappa Nu, 22, single. Three summers experience operating elec substations. Desires any type of engg work. Have references. Available immediately. Location immaterial. D-2140-335-C-1-San Francisco

B.S. in E.E. 1932, B.S. in M.E. 1933, Delaware, Honor student, Phi Kappa Phi, Varsity athlete, 22, single. Desires work in either elec or mech. engg. Available June 15. Location immaterial. References available. D-2139

E.E. GRAD. 1929, G.E. test experience, including work in radio and vacuum tube engg depts. and with all types of elec machy. Utility elec rate analysis experience covering pwr. cos. in all states. Received M.S. in June 1932. Wishes opportunity of any kind—anywhere, to which the above basic training might be applied. D-1036

TRANSPORTATION FIELD is my objective. 1932 E.E. Grad., 25, married. Telephone co. and pwr. substation experience. Can write French. Now employed in another field but wish to make the change as soon as possible. D-612

E.E. GRAD., 1931, 25, single, desires telephone, sound, radio, other elec work, or office work. Have experience in telephone installation, wiring, testboard, engg, and business office depts. Salary and location secondary. D-2074

E.E. GRAD. 1929, 25, single, Westinghouse grad. student training course. Experience in relay and automatic switching applications, and refrigeration development. Tech. work desired, any location. D-2101

M.A. and B.S. in E.E., 25, single. Broad education and experience, good record. Four yr Bell System, 1 yr elec mfg. and development. Interested appraisal, air conditioning, refrigerating, utility mech. engg, or other work. Also experienced secretarial and traffic. Excellent references. Location and salary immaterial. D-1475

B.S. in E.E., Purdue 1933. Majored in pwr. transmission and distribution, and accounting. Three summers experience with operating co. Desires employment with electric utility company. D-2103

PURDUE GRAD., 1929, B.S. of E.E., age 26, single. Six mos. with radio mfr., one yr, extensive utility training course, six mos. in engg office. References. Desires employment with utility or mfr. D-1801

E.E. GRAD. B.S. 1933 Wash. Univ., St. Louis, 23, single. Earned col. tuition. Member Tau Beta Pi, Pi Mu Epsilon. Excellent scholastic record. Good references at col. and elsewhere. Qualities of leadership, honesty, reliability. Has knowledge of operational math. Desires work, elec engg. Location immaterial. Salary reasonable, willing to earn it. D-2143

GRAD. CIVIL AND E.E., Univ. of Mich., 23, single. Two yr practical experience with Bell System. Interested in structural, ry., and hydroelec work. Open to anything in civil or elec field. Free to travel. References. D-2144

Maintenance and Operation

ENGR, B.S. (E.E.) U. of Colo., 1929, 26, married, family. Westinghouse engg school and elec design school; 2 yr design of pwr, distribution, network and testing transformers with large mfg. co. Desires position with any small co. using elec engr. Willing to start at bottom. Will accept work anywhere, immediately. D-1866

Production

PRODUCTION MGR. OR SUPT. Eighteen yr experience in charge of production of elec switches, transformers, and X ray machines, also have designing experience. Graduate of G.E. mech. and elec courses. Excellent references. Age 46, married. Prefer location in New England. Salary open. D-2129

Research

TECH GRAD., single, 10 yr experience with leading elec mfr. in the repair and testing of elec apparatus, 1 1/2 yr G.E. test. Desires position in testing and experimental work on motors, generators, etc. Any connection considered where experience would prove useful. Initial salary secondary to future prospects. C-8778

B.S. in E.E., Lehigh, 1932; honor student, Eta Kappa Nu; 30, single. Addl. Ch.E. training; 6 yr Bell System, asst. engr. Mech. aptitude; good lab. worker. Radio enthusiast. Command of English; typist. Suited research, development, but welcome any engg or lab. work. N. Y. area or 100-mile radius pref. D-2116

Sales

SALES ENGR, 25 yr business and engg experience, fine sales record at low cost; will locate anywhere in Middle West or East; well acquainted in western Pa., Ohio, and W. Va.; apparatus, control, motors, batteries, hoists, cranes, material handling, etc. B-5379

SALES ENGR, E.E. GRAD., 30, married, 5 1/2 yr experience in utility work involving pwr. station operation and maintenance; pwr. station and substation design. Teaching experience. Fourteen mos. application sales engg experience with control mfg. concern. Desires position as salesman or application engr. Available immediately. D-713

Membership

Recommended for Transfer

The board of examiners, at its meeting of May 17, 1933, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed with the national secretary at once.

To Grade of Fellow

Bundy, Edwin S., elec and operating engr, Buffalo, Niagara & Eastern Pwr. Corp., Buffalo, N. Y.
Carson, John R., transmission theory engr, Am. Tel. & Tel. Co., New York
Cooper, Ashton B., genl. mgr. and vice-pres., Ferranti Elec. Ltd., Toronto, Ont.
Emerson, Cherry L., vice-pres., and chief engr, Robert & Co., Inc., Atlanta, Ga.
Johnson, Tomlison F., pres. and owner, Johnson Mfg. Co., Atlanta, Ga.
Peebles, John B., prof. of E.E., Emory Univ., Emory Univ., Ga.

To Grade of Member

Bagnall, Fred W., overhead lines dept., Detroit Edison Co., Detroit, Mich.
Black, Harold S., member of tech. staff, Bell Tel. Labs., Inc., New York
Brown, Charles D., E.E., Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.
Buchanan, Arthur B., radio engr, Detroit Edison Co., Detroit, Mich.
Chute, George M., Jr., application engr, Genl. Elec. Co., Detroit, Mich.
Dodd, Roy L., supt., of underground division, Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.
Gilcrest, Charles F., supt., meter dept., San Joaquin Lt. & Pwr. Corp., Fresno, Calif.
Jackson, Wilson A., supt., telegraph, N. Y. C. R. R., M. C. R. R., C. C. C & St. L. Ry., I. H. B. R. R., Detroit, Mich.
Kostko, Jaroslaw K., asst. prof. of E. E., Washington Univ., St. Louis, Mo.
Likely, Robert D., engg. asst. to genl. supt., San Joaquin Lt. & Pwr. Corp., Fresno, Calif.
Manderfeld, Emanuel C., development engr, Electrical Research Products, Inc., Hollywood, Calif.
Phillips, Lester L., designer, Genl. Elec. Co., Pittsfield, Mass.
Piper, William J., engr, meter dept., Detroit Edison Co., Detroit, Mich.
Schulenberg, Wm. A., genl. mgr., AEG, Cia. Mexicana de Electricidad, S. A., Mexico, D. F. Mexico
Smalley, Dunlap D., division supt., Midland Counties Pub. Serv. Corp., Santa Maria, Calif.
Smith, John B., E.E., Southern Indiana Gas & Elec. Co., Evansville, Ind.
Teommey, George H., Jr., engg, asst., Brooklyn Edison Co., Brooklyn, N. Y.
Wagley, Oswal O., supt. of pwr. sales, Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.
Ward, Owen M., supt. of operation, Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before June 30, 1933.

Bryan, H. G., 527 Park Ave., Loveland, O.
Bukley, E. J., Mass. Inst. of Tech., Cambridge.
Chanaberry, R. W., Ky. Actuarial Bureau, Louisville.
Davis, K. C., Genl. Elec. Co., Toledo, O.
Dunlap, L. P., Western Elec. Co., Kearny, N. J.
Flynn, J. V., St. Bonaventure Col., Allegany, N. Y.
Forman, A. M., Harnischfeger Corp., Milwaukee, Wis.
Garrison, R. MacD., c/o J. H. McEvoy & Co., Houston, Texas.
Honer, G. T., Lake Shore Mines, Ltd., Kirkland Lake, Ont., Can.
Hughes, R., Hartford Steam Boiler Insp. & Ins. Co., Pittsburgh, Pa.
Knoff, R. R., Univ. of Wis., Madison.

Lentz, E. T., The Ohio Bell Tel. Co., Toledo.
Lyden, D. R., N. Y. & Q. Elec. Lt. & Pwr. Co., Flushing, N. Y.
Mariano, T. S., Box 343, Iowa City, Ia.
Morton, W. E., W. V. Pangborne & Co., Inc., Phila., Pa.
Parker, J. C., Canal Dredging Co., Pahohee, Fla.
Plummer, P. V., United Illum. Co., English Sta., New Haven, Conn.
Quigley, F. P. (Member), Engrs. Club of Phila., Pa.
Rose, J. J., N. Y. & Q. Elec. Lt. & Pwr. Co., Flushing, N. Y.
Silverman, D., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Solovieff, I. I., Mass. Inst. of Tech., Cambridge.
Stevens, Boyd, Ill. Bell Tel. Co., Champaign.
Sulewsky, F. W., T. M. E. R. & L. Co., Milwaukee, Wis.
Sulewsky, P. H., T. M. E. R. & L. Co., Milwaukee, Wis.
Voevodin, P. I. (Member), Am. Eng. & Industry, N. Y. City.
Wallace, C., Am. Tel. & Tel. Co., N. Y. City.
Whittaker, E. S., T. E. R. A. Project of N. Y. S. D. P. W. Div. 5, Springville, N. Y.
Wiltse, L. H. (Member), Zinsmeyer, Inc., Los Angeles, Calif.

28 Domestic

Foreign

Abideen, S., Pub. Wks. Dept., Central Provinces, India.
Akre, E. O., Mexican Lt. & Pwr. Co., Mexico City, D. F., Mexico.
Champion, C. H. (Fellow), Charles H. Champion & Co., Ltd.; Ship Carbon Co. of Great Britain, Ltd., London, W. 1, Eng.
Cresswell, A. J., Erina Shire Council, Gosford, N. S. W., Australia
Cuneo, E. W., Calle San Nicolas No. 24, Pergamino, Argentina, S. A.
Dave, B. B. (Member), Gujarat Ginning Mills, Post Ry. Pira, Ahmedabad, India.
Denyssen, Ivanhoe P., 376 Mountain View, Pretoria, So. Africa.
El-Deen, S. M., Metro-Vickers Co., Ltd., Trafford Park, Manchester, Eng.
Moorman, H. R., c/o Lage Petroleum Corp., Maracaibo, Venezuela, S. A.
Prache, P. M., Forges et Ateliers de Constructions Electriques Jeumont, Nord, France.
Saldana, A. E., Cia Colombiana de Electricidad, Apartado No. 739, Barranquilla, Columbia, S. A.
Simonsen, O., Box 466, Ancon, Canal Zone.
Singh, G., Gurbaksh Singh & Co., Dehradun, U. P., India.
Singh, L. (Member), Punjab Pub. Wks. Dept., Batala City, Punjab, India.
Smith, D. S., c/o A. Reyrolle & Co. Ltd., Hebburn-on-Tyne, England.
Sorabji, R., 375 De Lisle Rd., P. O. Jacob Circle, Bombay, India.
Venkataramayya, P., Hydroelectric Dept., Chepauk, Madras, India.
Widgery, R. G. (Member), Kingston-Upon-Thames Corp., Kingston-on-Thames, Surrey, Eng.

18 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Anderson, Geo. H., 131 Wenonah Road, Longmeadow, Mass.
Biavati, Jos. D., 22162—91st Rd., Queens Village, N. Y.
Bitner, Ralph E., Box 507, Port Washington, L. I., N. Y.
Buel, Kenneth F., 4621 Westminster, Pl. St. Louis, Mo.
Cannizzo, Mario, Trumbull-Vanderpoel Elec. Co., Bantam, Conn.
Carroll, J. G., 1537 Walnut St., Kansas City, Mo.
Child, Jos. E., 915 Alder, Seattle, Wash.
Danstedt, R. T., Y. M. C. A. Col. of Engg., 2200 Prospect Ave., Cleveland, Ohio.
Durant, Wm. T., 736 Broadway Ave., Regina, Sask., Can.
Harcus, Wilmore C., United Artists Studio, 1041 N. Formosa Ave., Hollywood, Calif.
Hardey, John Ernest, Box 551, Wellington, N. Z.
Herrington, L. B., Jr., Kentucky Utilities Co., Louisville, Ky.
Johansen, Harold C., 119 E. 10th St., Marion, Ind.
Nelson, Forrest S., 63 Boyd St., Worcester, Mass.
Parker, Ray H., 5355 Poinsette Ave., Richmond, Calif.
Victors, Peter, 420 Presidio Ave., San Francisco, Calif.
Vincent, Henry L., E. 916—19th St., Spokane, Wash.

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during April are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Der CHEMIE INGENIEUR. Bd. 2, Pt. 2. (Mengenmessungen im Betriebe, by R. Witte and E. Padelt.) By A. Eucken and M. Jakob. Leipzig, Akademische Verlagsgesellschaft, 1933. 274 p., illus., 10x7 in., cloth, 27.60 rm. The handbook of chemical engineering, of which this volume is a part, is intended to present in orderly arrangement the physical processes used in chemical and related factories. The present section is concerned with methods of weighing and of measuring volume and flow.

ERINNERUNGEN an die INTERNATIONALE ELEKTRIZITÄTSAUSSTELLUNG im GLASPALAST zu MÜNCHEN im JAHRE 1882. (Deutsches Museum Abhandlungen und Berichte, Jg. 4, Heft 6.) By O. V. Miller. Berlin, VDI-Verlag, 1932. 153–81 p., illus., 8x6 in., paper, 0.90 rm. Dr. von Miller, who first proposed the idea of this, the first electrical exposition to be held on German soil, has written an interesting account of its organization, of the exhibits and of its influence upon the future development of electrical engineering.

PAST YEARS, an Autobiography. By Sir Oliver Lodge. N. Y., Charles Scribner's Sons, 1932. 364 p., illus., 9x6 in., cloth, $3.50. Sir Oliver tells an interesting story of his boyhood, his efforts to obtain a scientific education, his busy years of electrical research at Liverpool, and his later investigations of psychic phenomena.

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS GUIDE, 1933, V. 11. N. Y., Am. Soc. of Heating and Ventilating Eng. 765 p., illus., 9x6 in., lea., $5.00. The new edition of this well known reference book is patterned upon previous ones, but the text has been thoroughly revised. New information on transmission losses, heating boilers, ventilation and air conditioning has been incorporated. In addition to the technical data, the book includes catalog data from manufacturers and the membership roll of the Society.

ATOM and COSMOS, the World of Modern Physics. By H. Reichenbach; translated and revised by E. S. Allen. N. Y., Macmillan Co., 1933. 300 p., illus., 8x6 in., cloth, $2.00. Attempts to explain the significance to modern life and thought of recent discoveries in physics. The accomplishments of the major physicists of the day are analyzed, and the new theories are presented. The work is founded upon lectures broadcast from Berlin, and is intended for laymen.

ATMOSPHERIC ELECTRICITY. By B. F. J. Schonland. London, Methuen & Co.; N. Y., E. P. Dutton & Co., 1932. 100 p., illus., 7x4 in., cloth, $1.10. A brief up-to-date review of developments in this subject, intended for readers of average scientific attainments. The book will enable the reader not in close contact with recent work to learn the modern position quickly and will open the way for further study.

COMMISSION INTERNATIONALE de l'ÉCLAIRAGE en Succession à la Commission Internationale de Photométrie. 8th Session, Cambridge, Sept. 1931. RECUEIL des TRAVAUX et COMPTE RENDU des SÉANCES. Cambridge, Eng., Univ. Press, 1932. 693 p., illus., 10x6 in., cloth, 20s. Contains the proceedings of the Cambridge meeting of the Commission, the official recommendations adopted, and the reports presented by the various national committees. Among these were reports on street lighting, daylight illumination, the vocabulary of illumination, applications of lighting, colored glasses for signals, traffic signs, glare, aviation lighting, and various problems of photometry.

COMMUNICATION AGENCIES and SOCIAL LIFE. By M. M. Willey and S. A. Rice. N. Y. and Lond., McGraw-Hill Book Co., 1933. 229 p., illus., 9x6 in., cloth, 12.50. This volume presents the scientific information on communication assembled for the President's research committee on social trends. The data unearthed and the findings derived from them are here presented more fully than could be done in the general report. Our transportation agencies and their utilization, our postal, telegraph and telephone systems, radio, newspapers, periodicals, and motion pictures are considered and their effects upon us examined.

GREAT DELUSION, Some Facts about Government in Business. By E. Greenwood. N. Y. and Lond., Harper & Bros., 1933. 238 p., 8x5 in., cloth, $2.50. This work discusses the relation of government to business and to the regulation of business. The author is alarmed at the gradual intrusion of government into business which is occurring and by its efforts to regulate or compete with private initiative. He presents the case against government ownership forcibly and readably. His illustrations are drawn chiefly from the electric power industry.

HYDRAULIC MACHINERY. By D. W. Mead. N. Y. & Lond., McGraw-Hill Book Co., 1933. 396 p., illus., 10x6 in., cloth, $4.00. Deals with the general principles of hydraulic machinery and with methods of generating and using power in general, and discusses pumping machinery, with special attention to small installations. Written from the point of view of the purchaser. Prepared primarily for students.

INDUSTRIAL ELECTRIC HEATING. By N. R. Stansel. N. Y., John Wiley & Sons, 1933. 444 p., illus., 9x6 in., cloth, $5.00. Revised presentation of a series of articles which appeared in the *Genl. Elec. Rev*. The more important principles of thermal engineering are reviewed briefly, followed by a discussion of the construction of the various types of electric furnaces and of their uses, with examples of their application. Low-temperature heating, induction heating of solids, the production of ferro-alloys and some other phases of heating are not included.

IRON and STEEL (a pocket encyclopedia). By H. P. Tiemann. 3 ed. N. Y. & Lond., McGraw-Hill Book Co., 1933. 590 p., illus., 7x4 in., lea., $4.00. Under an alphabetical arrangement, it provides definitions and brief, clear descriptions of the processes and methods of the industry, of the technical terms used and of terms related to allied sciences, fulfilling the purposes of a dictionary and an encyclopedia. The new edition has been carefully revised.

PLANNING PROBLEMS of TOWN, CITY and REGION, presented at the twenty-fourth National Conference on City Planning, Pittsburgh, Nov. 14–16, 1932. Phila., Wm. F. Fell Co., 1932. 158 p., illus., 9x6 in., cloth, $3.00. Twenty-one experts present their views upon a variety of subjects. The relation of planning to housing programs and to taxes, budgeting, methods of making planning more effective, the range of the planning field, and other topics are discussed.

PRINCIPLES of INDUSTRIAL MANAGEMENT. By E. A. Allcut. Lond., Toronto and N. Y., Isaac Pitman & Sons, 1932. 218 p., illus., 9x6 in., lea., $3.00. A textbook for students giving a good, concise presentation of principles, without attempting to describe the details of industrial administration. Others desirous of some general knowledge of the subject will find it useful.

TEXTILE ELECTRIFICATION. By W. Stiel, translated by A. F. Rodger. Lond., George Routledge & Sons, Ltd., 1933. 608 p., illus., 11x7 in., cloth, 63s. A combination of electrical engineering and textile technology, written to show the benefits accruing from the application of electricity in all branches of the industry.

Engineering Societies Library

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

Industrial Notes

Allis-Chalmers Transfers Representative.—L. H. States, formerly connected with the Philadelphia office of the Allis-Chalmers Mfg. Co. of Milwaukee, has transferred to Syracuse, N. Y. He will handle the principal products of the company for the central part of that state.

Spectacular Electric Sign for Chicago.—The largest electrical spectacular sign in the middle west is being erected by Standard Oil at the north end of Grant Park in Chicago. Overall dimensions of 200x136 ft give the sign a height equal to that of a 14-story building and a length of half an ordinary city block. The torch which is a dominant feature is 136 ft high. Words are made up of letters 16 and 18 ft high, with a total weight of 80 tons. The supporting structure weighs 120 tons, giving the entire sign a weight of 200 tons. Approximately $^1/_2$ mile of neon tubing, together with 8,000 incandescent lights will provide a brilliant display of colors in the night lighting. Connections involve use of 14 miles of wiring and cable, and current consumption of 250 kw.

A New Line of A-C Generators.—A new line of a-c generators has been announced by the Marble-Card Electric Co., Gladstone, Mich., ranging from 0.6 kva to 75 kva capacity. The generators are of the separately excited type and have the d-c exciter bolted directly to the main generator frame. Three-phase, 3-wire and 4-wire machines, as well as single-phase, 2- and 3-wire types, are built in all standard sizes up to 75 kva, 3 phase, and up to 50 kva, single phase, and in addition to these standard machines many other sizes with special characteristics are built for manufacturers of engine-driven generator sets.

New Type Feeder Regulator.—The Allis-Chalmers Mfg. Co., Milwaukee, has developed a new type automatic feeder voltage regulator for applications where the induction type of regulator has heretofore been used. In addition the Allis-Chalmers unit can be used on higher operating voltages than those for which the induction regulator can be economically designed. The equipment operates on the basis of an automatic tap changing device with suitable transformers, all built into a small compact unit and is applicable to either indoor or outdoor use and for single-phase or 3-phase operation.

Olsen Testing Equipment at Fair.—The most recent developments in both universal testing and balancing equipment will be exhibited and demonstrated at the "Century of Progress" Exposition, Chicago, by the Tinius Olsen Testing Machine Co., Philadelphia. One of the largest type Olsen-Lundgren dynamic balancing machines will be demonstrated, which is of the compensating weight type and electrical control by push button. The new special Olsen dynamic balancing machine which has never been exhibited before will be demonstrated for balancing of light weight parts. This machine records the amount of unbalance by a special patented electrical method. A special type Olsen static balancing machine will be demonstrated for use in balancing flywheels, clutches, etc., where the entire checking and correcting operation can be determined on the machine without removal of the part being balanced.

Other equipment on view will include a 60,000 lb capacity universal testing machine with pendulum weighing system, hydraulic loading and all latest attachments. A smaller machine of 2,000 lb capacity, for testing fine wire, fabrics, etc., will also be demonstrated. Hardness testing equipment for various materials will be shown, as well as ductility testing apparatus and various types of strain gages, extensometers, and instruments.

Supersensitivity.—Formerly the use of a few hundred volts was necessary in the measurement of resistances amounting to a billion ohms, and it was hardly possible to measure resistances of decidedly higher values. Now, with a supersensitive amplifier produced in the general engineering laboratory of the General Electric Company at Schenectady, it is possible to measure resistances of a trillion ohms, with only about one volt impressed. The amplifier incorporates a type FP-54 (10^{-17} ampere) 4-electrode tube. Its applications include the measurement of phototube currents in astronomical determinations of starlight, measurement of radium and X-ray emanations, study of cosmic rays, etc.

In combination with a commercial type of galvanometer, the supersensitive amplifier makes possible the measurement of currents as small as 10^{-15} amp, and when used with a suitable sensitive galvanometer this range may be extended to 10^{-17} amp. The amplifier is compact, portable, and easy to use. So sensitive is the device, a person moving about the room would produce readings greater than those of the input circuit, were the amplifier not thoroughly shielded.

Trade Literature

Induction Motors.—Bulletin GEA-1695, 4 pp. Describes G-E quiet induction motors, squirrel-cage and wound-rotor, $^1/_2$ to 50 hp; single-phase $^1/_2$ to 10 hp. General Electric Co., Schenectady, N. Y.

Railway Air Conditioning Equipment.—Bulletin C. 1967, 12 pp. Describes Westinghouse railway car air conditioning equipment. Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Manhole Ventilator.—Bulletin 166, 2 pp. Describes a new portable, gasoline engine driven cable manhole ventilator for ventilating and driving noxious fumes from confined working spaces. Coppus Engineering Corp., Worcester, Mass.

Trolley Coaches.—Bulletin GES-879, 8 pp. Describes G-E equipment for trackless trolley coaches. An analysis of the trolley coach as a transportation tool is included, as well as the views of operators. General Electric Co., Schenectady, N. Y.

Gear Motors.—Bulletin 400, 4 pp. Describes a new line of gear motors, $^3/_4$ hp and up. Motor and speed reducer are combined into one compact, fully protected unit. Reliance Electric & Engineering Co., 1042 Ivanhoe Rd., Cleveland, O.

Lightning Protection for Distribution Transformers.—Bulletin 354, 32 pp. Described as a comprehensive treatment of the subject; illustrates Crystal Valve lightning arresters as installed in distribution transformers of a number of manufacturers. Electric Service Supplies Co., 17th and Cambria Sts., Philadelphia, Pa.

Photolux Control of Lighting.—Bulletin L. 20579, 4 pp. Describes the Westinghouse "Photolux," a reliable and accurate device that operates to turn electric lights on or off when daylight decreases or increases in intensity to a predetermined value. Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Metal-Clad Switchgear.—Bulletin 533. Describes the metal-clad switchgear employed in a new California generating station, employing 7,000-hp, 8-cylinder, double-acting, 2-cycle Diesel engines. Delta-Star Electric Co., 2400 Block, Chicago, Ill.

Brewery Equipment.—Bulletin 149, 12 pp., "Equipment for the Modern Brewery and Malt House." Describes apparatus for the power, electrical, pumping, and other requirements of the brewing industry. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Solder Temperature Tester.—Bulletin. Describes the "Temperometer" for indicating temperature of solder for wiping cable joints. The device is a simple tube, 10 in. long, which is placed in the molten solder and registers the correct temperature. Dillon Mfg. Co., 63 E. Lake St., Chicago, Ill.

Telemetering.—Bulletin 874, 16 pp., on "Telemetering and Totalizing Station Loads." Means are discussed for providing the load dispatcher of an electric power system with continuous information on load conditions throughout the system, to facilitate load distribution in ordinary conditions, and to aid in control of emergencies. The bulletin describes apparatus for local recording of the outputs of generating units, stations and tie lines, for transmitting the records to the load dispatcher's office, and for combining them into the total for the system. It gives a brief but comprehensive explanation, with schematic diagram of the method employed for telemetering and totalizing. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

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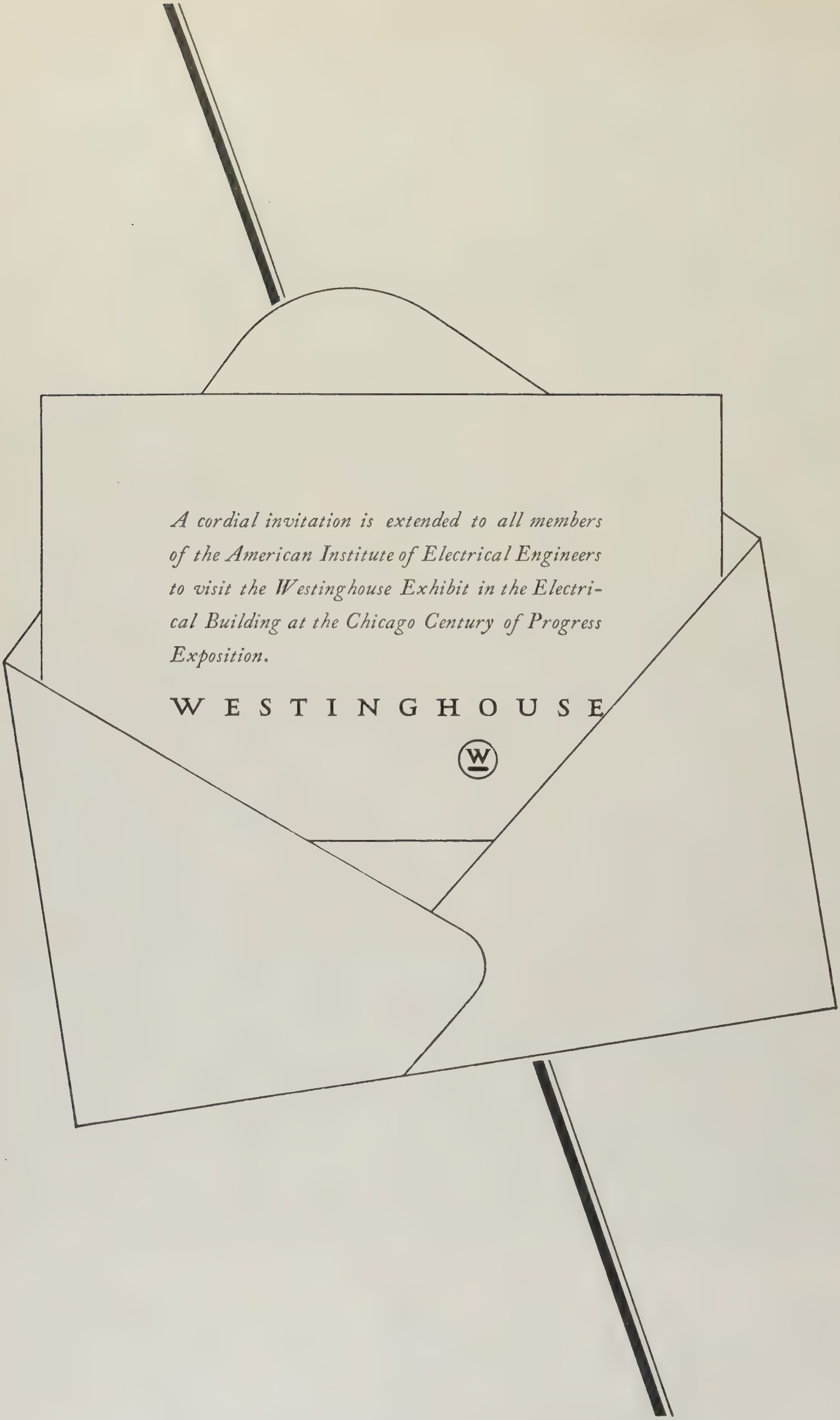
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THE STANDARDS of the American Institute of Electrical Engineers now consist of forty sections on electrical machinery and apparatus. They are chiefly devoted to defining terms, conditions, and limits which characterize behavior with special reference to acceptance tests. Many of the standards are recognized officially as American standards.

The Standards available are listed opposite, together with prices. A discount of 50% is allowed to Institute members. Such discount is not applicable on extra copies unless ordered for other members. Numbers of the Standards Sections should be given when ordering.

• • •

Sections in Preparation

Nine such sections are now available in report form for purpose of criticism, and copies will be sent without charge upon request, with the exception of No. 2, for which there is a non-member charge of $1.00, with usual 50% discount to members. These sections are as follows:

No.		
2	(Aug. 1932) Electrical Definitions..	$1.00
17g2	Graphical Symbols Used for Electric Power and Wiring. (Revised July 1930.)	
17g3	Graphical Symbols Used in Radio Communication.	
17g5	Graphical Symbols Used for Electric Traction Including Railway Signaling.	
18	Capacitors.	
23	Relays.	
28	Lightning Arresters.	
—	Test Code for Transformers.	
—	Test Code for Synchronous Machines.	

A binder for standards is available. The stiff covers are finished in a long wearing material resembling leather, suitably lettered in gold. The price is $1.75 net.

No.		
1	General Principles Upon Which Temperature Limits Are Based in the Rating of Electrical Machinery..........	$ 0.20
4	Measurement of Test Voltage in Dielectric Tests........	.30
5	D-C Generators and Motors and D-C Commutator Machines in General..............................	.40
7	Alternators, Synchronous Motors and Synchronous Machines in General................................	.40
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9	Induction Motors and Induction Machines in General...	.40
10	D-C and A-C Fractional Horse Power Motors..........	.30
*11	Railway Motors..................................	.30
12	Constant Current Transformers......................	.30
13	Transformers, Induction Regulators and Reactors.......	.40
*14	Instrument Transformers...........................	.30
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*61	Specifications for Soft or Annealed Copper Wire. (Nos. 60 and 61 published as one pamphlet)...............	.30
*63	Specifications for 30 Per Cent Rubber Insulation for Wire and Cable for General Purposes....................	.30
*69	Specifications for Cotton Covered Round Copper Magnet Wire. (See No. 71 for price.)	
*70	Specifications for Silk Covered Round Copper Magnet Wire. (See No. 71 for price.)	
*71	Specifications for Enameled Round Copper Magnet Wire. (Nos. 69, 70 and 71 published as one pamphlet)......	.30
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